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The Future for Castings

At the Sheffield Conference of the Institute of British Foundrymen, Prof. Andrew asked Dr. Hatfield whether castings could ever hope, in a general way, to replace wrought materials. To this question Dr. Hatfield gave an unqualified answer in the negative; yet we feel sure that it was the breadth of the terms of reference which made Dr. Hatfield seem so dogmatic. For general structural work, unless the shape be too complicated for a standard structural part to be used, castings will always be needed. In general engineering, for those parts which have to withstand static stresses only, and especially where mass is desirable to minimise the effect of vibration, castings will be used increasingly, as the fashion for eliminating weight has passed its zenith. Where castings can be made by quantity-production methods, they will make inroads into the field now held by drop-forgings and weldings on account of cost. The scrap made by other processes introduces an extravagance only realised when one is inspecting Ward's or Cohen's yards.

The consumption of malleable cast iron in Great Britain is still much lower than in other manufacturing countries, and as its properties become more widely known and better appreciated, increased consumption can be looked for at the expense of wrought material. What the Professor had in mind, however, was the extraordinary development recently registered in the utilisation of castings for crankshafts by the automobile industry, and the return to steel castings as a material best suited for valves having to withstand high pressures and temperatures, after extensive trials with wrought material. For tool steels, not castings, but agglomerations such as tungsten carbide have made some headway at the expense of the wrought materials, and we have seen a specialised foundry in Sheffield busily casting cutting tools! We have also seen a foundry in the Birmingham area casting scissors, the lettering thereon being clearer and sharper than most lettering impressed upon the forged article. Despite the above, Dr. Hatfield is perfectly correct in his assertion, but we feel sure that he would agree that to-day the foundry has made such progress that a well-made steel casting can, and does, show better properties than either a badly-made forging or one made from dirty steel.

The Entrance to Industry—I

The non-party group known as Political and Economic Planning has recently issued two reports that have received a good deal of attention under the titles "The Entrance to Industry" and "The Exit from Industry." Industrialists now accept the necessity for the State to prepare young people for industrial life, to take care as far as practicable of their old age, and to maintain them during spells of unemployment. With a core of unemployment still existing of some two millions, and with many people demanding a shorter working week to offset the greater productivity of the industrial machine, it is obvious that the regulation of ages of entrance to and exit from industry offers a method of controlling the number of people available for industrial employment, and hence of partially solving the unemployment problem, without recourse to really drastic proposals such as the shorter working week. This latter proposal cannot really be settled without international agreement, and even if that is forthcoming it will take a long time.

The conclusions arrived at by the examination referred to above are as follow. Although the age 14 to 18 is an important one in the growth of young people, only a small proportion continue their education after 14. While some become connected with voluntary day continuation schools, part-time day classes, evening classes or voluntary organisations, most have no association at all with educational, leisure or welfare institutions. There is no regular supervision of health or provision for organised games. Entrance to industry is still an unorganised scramble. As the population shrinks, the 14-18 group will get smaller in relation to total population, and any waste or frustration through unemployment or misemployment will be less tolerable. The existence of unemployment among adults makes it less excusable than ever to exploit young people as wage-earners during the period in which they should be trained.

It is suggested that during 14 to 18 there should be a definite educational influence in the lives of young people and that health should be supervised and an organised system of industrial recruiting, training and welfare started. Bearing in mind the schemes which have been put forward in recent years, there is nothing revolutionary in the proposals, and we intend to deal with them and with the proposals for governing the exit of older workers from industry in subsequent issues. So far as the educational proposals are concerned, it is stated that half the cost at least would be saved on unemployment benefit, and possibly three-quarters.

XUM

Patternshop Economies

By A. BUCKLEY

Much time and ink has been spent in the discussion of the working costs of that Cinderella of the engineering industry, the patternshop, but in many cases misapplied economy is in itself one of the causes of high working costs. Thus, a little judicious expenditure on what one might term the minor equipment of the patternshop would often result in a saving, which would be noticeably in evidence once the men had accustomed themselves to the innovations provided.

Glue Pots and Greasing

For instance, in one patternshop with which the writer has been acquainted, the system in vogue for heating the glue consisted of a number of electric kettles placed at intervals around the shop. Now these kettles contained but one single heating element and were turned on at starting time each day, but one hour must of necessity have elapsed before the glue was of the correct consistency for use. Consequently, any work requiring glue was held up for at least one hour, which could be regarded as one hour lost time, for in many cases it was found that the workmen had not sufficient other tasks with which to occupy their time during this period, as would be the case when engaged on built-up work.

In the same shop a labourer was fully engaged during the first half hour of each day greasing the machinery, and during this period workmen who wished to use the machines were constantly being held up until the greasing operation was completed. The cutting out of this early-morning loss of time involved a small expenditure, but this was recovered in a very short period in the resultant saving of time.

In an endeavour to mitigate losses of this description the management, after consultation, embarked upon the policy of providing additional facilities for the more rapid melting of glue by installing glue kettles of the four-heater-element type, a policy which proved itself long overdue, since it was found that by this adoption the glue was ready for use in one-quarter the time originally demanded for the older method. Furthermore, there was an appreciable saving in current as it was now found possible to take full advantage of the low and medium stages of the new heater element. The labourer was detailed off to commence duties half an hour earlier than the workmen in order to switch on the glue kettles and to complete the greasing of the machinery before the recognised starting time. The expenditure in this case alone consisted solely of the capital outlay for the four-heater element and, of course, the additional remuneration in the form of wages incidental to the earlier hour at which the labourer commenced his duties.

In most patternshops there is to be found an assortment of old screws, usually everybody's property, but for which no one appears to assume responsibility, and usually obtained from the demolition of old patterns, etc. These are generally dumped in some odd corner and regarded as so much scrap. In the shop under consideration these were dealt with as follows. A labourer was provided with a fine riddle and told to grade them and place them into various boxes, suitably indexed, according to size. The boxes were placed in an accessible position and the men encouraged to use these screws whenever possible. The saving effected by so doing easily discounted the labour involved.

Planing and Sandpapering

Another source of lost time amongst the workmen was traced to men having to wait around until the planing-machine blades, which had been taken out for purposes of grinding and re-sharpening, were replaced, and when the sand-papering machine was being re-papered a similar hold-up was discovered. The remedy was found to be in arranging for the machine-man to stay over for one hour twice weekly to attend to these renewals, thus leaving the machines available for continuous operation during the full working day.

The time saved by the installation of a universal woodworking machine need not be stressed herein as its usefulness is widely recognised. One point in connection with these machines must be borne in mind, however, when purchasing, that is, the supply of a complete set of cutters capable of performing any type of work which the machine may be called upon to do. Numerous occasions arise where the whole of a job that is within the scope of the machine cannot be executed owing to the lack of suitable cutters. This attitude of supplying an expensive machine and only half the necessary attachments is a very short-sighted one, for obviously full value cannot be obtained from a machine that is only working at half its capacity.

The band saw is undoubtedly the greatest time-saving machine in the patternshop, since its function is to cut out all manner of peculiar shapes accurately so that the wood requires very little attention after leaving the machine. To perform this task efficiently the saw itself must run true, and when through repeated breakages it becomes a string of short pieces brazed together, which cannot under any circumstances be made to run true, it should be scrapped. In the interests of true economy all machines should be kept in first-class condition and supplied with all the necessary equipment.

Timber Costs

The question of timber costs is a very vexed one. It is the practice in some shops to write off 2½ per cent. for waste, but with the quality which some firms buy, in an endeavour to keep down costs, this figure is raised to something nearer 30 per cent. Furthermore, this inferior quality of timber is a source of danger to the workmen, through shakes, loose knots and hidden cracks, when working on the machines. It is also one of the causes of inferior patterns, for what workman can make a sound job with poor materials, without spending a large amount of time putting on additional battens, cutting out large knots, and breaking and glueing cracks and shakes, thereby increasing the cost of labour?

It is the practice in some shops for the foreman or charge hand to set out the full-size working drawings of the patterns, but, whilst admitting that this practice saves the workman's time in the first instance, the writer is of the opinion that it is of ultimate advantage to let the workman set out his own drawings, for in so doing he obtains a thorough insight into the job in hand, which often saves a false start and which enables him to construct the pattern in the soundest and most expeditious manner.

Finally, the man in the shop is much more conversant with the impediments that mar the smooth running of the shop than the management. Therefore, his help should be enlisted in seeking out these obstacles, and with this object in view the following scheme is proposed.

Suggestion Box

A number of cards or sheets placed in a box from which they can be easily obtained at any time and an invitation to the workmen to make any suggestions upon the running of the shop thereon is a modern necessity. The suggestions solicited by this means should be subjected to periodic review by the management and be given the fullest consideration, and if at all practicable a trial, if only to encourage the workmen to maintain their interest in the working of the shop. Through this scheme many really worthwhile suggestions do come to light, but it is also to be expected that many suggestions will be of a frivolous or impracticable nature.

Quality of Electric Steel

ARC *v.* INDUCTION

Hans Diergarten, in the course of a letter to "Metal Progress," states that production of steel in coreless induction furnaces has continually increased in the last few years, particularly of high-quality steels and high-speed tool steels, and it is frequently alleged that the high-frequency steels are better than those made by other melting methods.

It is, of course, particularly important for the consumer to be able to evaluate the quality—a matter of considerable difficulty. In his own operations (SKF in Germany) his experience is to the effect that there is, in general, no difference between steels from the coreless induction and from the electric-arc furnace in so far as chemical composition, uniformity of structure, and carbide distribution are concerned. His experience is mainly concerned with high-speed and die steels.

Acid as well as basic melts of high-tungsten steels were made in high-frequency furnaces of different sizes—100 lbs. and 1 ton capacity at the Krupp Works and 1 and 4-ton furnaces at the Deutsche Edelstahlwerke—and these were compared with similar melts made in arc furnaces. At the Krupp plant, when melting 18 per cent. tungsten, 4 per cent. chromium, and 1 per cent. vanadium high-speed steel (as well as the 14-4-2 variety) it was discovered that melts from the coreless induction furnace had finer and more uniform carbide distribution than melts from arc furnaces. These extensive micrographic investigations were made on fields magnified 50 and 100 diameters.

Since the retention of hardness at red heat is important for good service of high-speed steel, experiments to determine this property were made and showed practically no difference.

A deciding factor in the quality of high-speed steel is its service as a cutting tool. To determine this the various steels were hardened at 2,300 to 2,350 deg. Fah. and drawn for 1 hr. at 1,050 deg. Fah. Other steels were quenched in oil from 2,375 deg. Fah. and drawn half an hour at 1,050 deg. Fah. Cutting tests were then made on a piece of chromium-nickel steel, heat-treated to a tensile strength of 65 tons ± 1.5 tons. Feed was 0.055 in. and depth of cut 0.200 in. Cutting speeds were 36, 45, and 52.5 ft. per min. These tests indicated no certain difference between high-frequency and electric-arc melted steels. Likewise no difference could be found between the basic and acid melted high-frequency steel.

Studies at the Krupp Works showed that only in the carbide distribution did the comparisons show more favourable results. This was attributed to the circular motion of the high-frequency bath, which presumably caused increased nuclear formation—that is to say, a greater number of nuclei resulted in a fine-grained crystallisation and therefore in a fine distribution of carbide. Slag content was somewhat higher in induction steel than in arc-melted steel of corresponding quality. This agrees with the writer's own experience.

Tests at the Deutsche Edelstahlwerke by R. Scherer covered three tool steels of the following composition: (*a*) W 14 per cent., Cr 4 per cent., V 1.5 per cent.; (*b*) W 23 per cent., Cr 4 per cent., V 1.5 per cent.; (*c*) W 13 per

(*Concluded on page 56.*)

Steel Castings, with Special Reference to Alloy Steels*

By DR. W. H. HATFIELD, F.R.S.

Introduction

The principal steel foundry of Messrs. Thos. Firth & John Brown, Limited, is situated at Scunthorpe, in Lincolnshire, and is, therefore, unfortunately too far from Sheffield for a visit from the Institute on this occasion. This is regretted, as it would have given the directors much pleasure to have had the opportunity of inviting the members to see the lay-out and steel-foundry methods in use. With the formation of Thos. Firth & John Brown Company, the Sheffield foundry of Messrs. Thos. Firth & Sons, Limited, was merged with that of Messrs. John Brown & Company at Scunthorpe, and much capital was expended in creating a joint foundry of first-class efficiency. Members are, however, visiting other steel foundries well representative of the best modern steel-foundry practice.

A few months ago, the author had the pleasure of presenting the exchange Paper with the United States upon this subject, and therefore found himself in some little difficulty as to exactly what aspects of the matter should be now dealt with. After consideration it was decided that, in view of the aspects dealt with by other writers of Papers for this Conference, the author might most usefully deal with the range of steels which are now available in cast form.

* A Paper read before the Annual Meeting of the Institute of British Foundrymen at Sheffield, July 2 to 5, 1935.

DR. W. H. HATFIELD, F.R.S.

To-day excellent steel castings are produced in practically all the steels which have been developed; the ordinary high-tensile alloy steels, wear-resisting steels, steels of special magnetic properties, corrosion- and acid-resisting steels, heat-resisting steels and many others. Indeed, the author welcomes this opportunity of indicating the extent of the success of the modern steel foundries in producing castings covering such a wide range of physical and other properties.

Alloy Steel Castings

Carbon-steel castings containing up to 0.40 per cent. of that element have a tensile strength from 28 to 40 tons per sq. in., coupled with reasonable ductility; but with the increase in carbon content the ductility becomes progressively less. It has, however, been found that by having resort to the addition of special elements to the composition of the steel, greater ductility can be obtained with greater tensile strength, and not only so, but by greater percentages of the added elements, entirely new characteristics are conferred.

In Table I some of the most important types of alloy steel are listed together with the mechanical properties which the steels possess in the condition in which they are usually put into service.

It will be noticed that in the steel, containing 1½ per cent. manganese, the same tensile strength as a 0.40 per cent. carbon steel is obtained by raising the manganese content to 1½ per cent. and lowering the carbon to 0.25 per cent. This drop in the carbon content, however, gives a marked increase in toughness. A similar steel containing 1½ per cent. manganese and 0.45 per cent. carbon is considerably harder, whilst still remaining reasonably tough.

What has already been written concerning the annealing of carbon steels applies with equal or greater force to alloy steels, and it must be understood that heat-treatment is the necessary

TABLE I.—*Properties of Heat-Resisting Steels.*

Class.	Analysis.	Heat-treatment to give service condition.	Mechanical properties.				
			M.S. Tons per sq. in.	Y.P. Tons per sq. in.	Elong. Per cent.	R. of A. Per cent.	Brinell.
Carbon Steel	0.20 per cent. C	Annealed 900 deg. C.	26/30	13/17	35/20	55/30	111/126
,, ,,	0.30 per cent. C	Annealed 890 deg. C.	29/34	14/18	28/18	45/24	121/149
,, ,,	0.40 per cent. C	Annealed 860 deg. C.	35/40	18/21	20/15	30/18	159/179
,, ,,	0.60 per cent. C	Annealed 840 deg. C.	45/50	—	—	—	196/225
,, ,,	0.75 per cent. C	Annealed 810 deg. C.	50/55	—	—	—	225/255
Alloy Steel	1½ per cent. Mn *a.* 0.25 per cent. C	Annealed 920 deg. C.	35/40	18/22	23/18	35/25	159/179
	b. 0.45 per cent. C	Annealed 900 deg. C.	40/50	20/28	15/10	25/15	183/229
		O.H. 870 deg. C. T. 600/650 deg. C.	50/60	30/40	15/10	25/15	229/277
,, ,,	Ni-Cr	Annealed 900 deg. C. O.H. 870 deg. C. T. 550/650 deg. C.	40/50	25/35	15/10	25/15	183/229
,, ,,	Ni-Cr-Mo	Annealed 900 deg. C. A.H. 870 deg. C. T. 550/650 deg. C.	50/60	35/50	18/10	30/15	229/277
,, ,,	C-Cr	Annealed 900 deg. C. O.H. 870 deg. C. T. 550/650 deg. C.	40/55	30/45	15/10	25/12	183/248
Rustless Steel	14 per cent. Cr Stainless	O.H. 960/980 deg. C. T. 700/750 deg. C.	40/45	20/25	25/20	45/35	183/207
,, ,,	18 per cent. Cr, 2 per cent. Ni to B.S.I. Specification S.80	O.H. 960/990 deg. C. T. 500/550 deg. C.	45/50	28/32	18/15	30/20	207/228
Acid-Resisting Steel	18 per cent. Cr, 8 per cent. Ni. "Staybrite" type	A.C. or W.Q. 1150 deg. C.	32/37	15/17	45/25	45/25	143/170
,, ,,	Special 18 per cent. Cr, 8 per cent. Ni, Welding Quality	A.C. or W.Q. 1050 deg. C.	37/42	16/19	25/15	25/15	170/192
Heat-Resisting Steel	26 per cent. Cr, 10 per cent. Ni	A.C. 1050 deg. C.	34/38	16/18	25/20	30/25	156/174
,, ,,	20/25 per cent. Cr, 8/12 per cent. Ni, 3/4 per cent. W	A.C. 1050 deg. C.	35/40	17/20	25/20	30/25	163/183
,, ,,	30 per cent. Cr	O.H. 1050 deg., T. 600/700 deg. C.	26/30	—	—	—	114/131
,, ,,	Nichrome (60 : 20 : 20)	A.C. 1000 deg. C.	22/32	18/27	10/2	—	138/180
High Permeability Steel	Low C	Annealed 900 deg. C.	24/28	13/16	35/25	55/35	103/116
High Temperature Steel	Mo *a.* 0.20 per cent. C	Annealed 900 deg. C. A.H. 870 deg., T. 650 deg. C.	32/38	17/26	26/20	42/30	143/174
	b. 0.30 per cent. C	Annealed 900 deg. C. A.H. 870 deg., T. 650 deg. C.	34/42	18/28	25/18	40/28	156/192
Shock Resisting Steel	Mn-Mo	Annealed 900 deg. C. A.H. 870 deg., T. 650 deg. C.	40/50	25/35	20/12	30/18	183/229
Wear-Resisting Steel	C-Cr	Annealed 920 deg. C. O.H. or A.H. 870/900 deg. C. T. 550/650 deg. C.	—	—	—	—	201/321 241/401
,, ,,	Austenitic Mn	W.Q. 1000 deg. C.	—	—	—	—	241 max.

complement of the alloy addition. Given correct heat-treatment, however, the table shows that greatly improved mechanical results are obtained.

FIG. 1.—GROUP OF GRINDING PLATES MADE IN CARBON-CHROMIUM AND AUSTENITIC-MANGANESE WEAR-RESISTING STEELS.

The 1½ per cent. manganese steels find useful application in various types of relatively heavily-loaded transmission gears and pinions, as well as for such details as excavator digger teeth which demand toughness as well as hardness.

The addition of nickel and chromium to steels, whilst raising the cost, nevertheless produces steels having a high yield point and great toughness; whilst the further addition of molybdenum again increases the possible strength of the material inducible by heat-treatment, and yields a steel suitable for the most severe conditions of stress combined with shock, such as are met with, particularly in many applications as, for instance, tractor and excavator machinery. Indeed, nickel-chromium and nickel-chromium-molybdenum steel castings are the ones which will stand up satisfactorily to the heavy duty experienced in caterpiller-tractor mechanisms.

Finally, the carbon-chromium steel listed in Table I is one which possesses, in addition to strength and toughness, the intrinsic hardness to withstand considerable wear, and is used, for instance, for cast-steel gear blanks.

Rust- and Acid-Resisting Steel Castings

It was not many years ago that steel castings subjected to corrosive conditions had either to be frequently replaced or the plant had to be designed to their exclusion. To-day, there are steels suitable for foundry work which resist the most corrosive conditions. In Table I the steam plant, and other similar conditions in which mildly-corrosive conditions are experienced.

The 18 per cent. chromium, 8 per cent. nickel steels, on the other hand, are acid-resisting, and

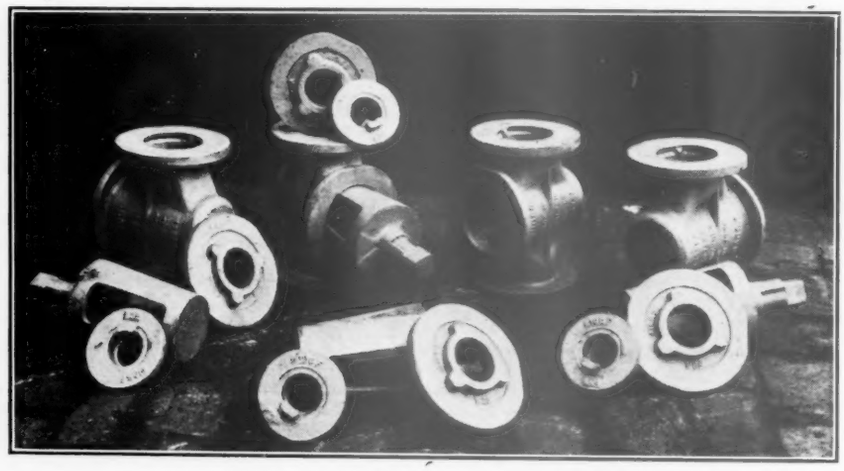

FIG. 3.—GROUP OF STAINLESS STEEL VALVES.

main types are illustrated. The ordinary 14 per cent. chromium steel is essentially a rust-resisting steel; that is to say, it is employed for such castings as those used in dock-gate assemblies, are employed in many applications in the chemical industry and also in all types of decorative work, such as window fasteners, door handles, hooks, taps and other bathroom fittings, as well as for such industrial work as pump castings, cast dye vats of special design, water wheels, etc. The founding of these steels presents a number of fascinating and interesting problems. At one end of the scale is the problem of setting a core in position so that a bathroom tap may be cast having a uniform wall thickness of about $\frac{3}{32}$ in.

At the other end is the problem of setting up the mould and cores for a turbine wheel weighing several tons, having a heavy hub and a heavy rim 7 or 8 ft. in dia., between which lie perhaps a dozen and a-half curved blades of light section, tapering to less than an inch in thickness at the trailing edge; upon the exact position and accuracy of these blades the efficiency of the whole machine depends. The problems would not be easily solved in a non-ferrous foundry, and they are much more difficult with a steel cast at a temperature between 1,600 and 1,700 deg. C. having a contraction on cooling of $\frac{3}{32}$ to $\frac{5}{16}$ in. per ft. Actually, both extremes and many intermediate types of such castings are produced.

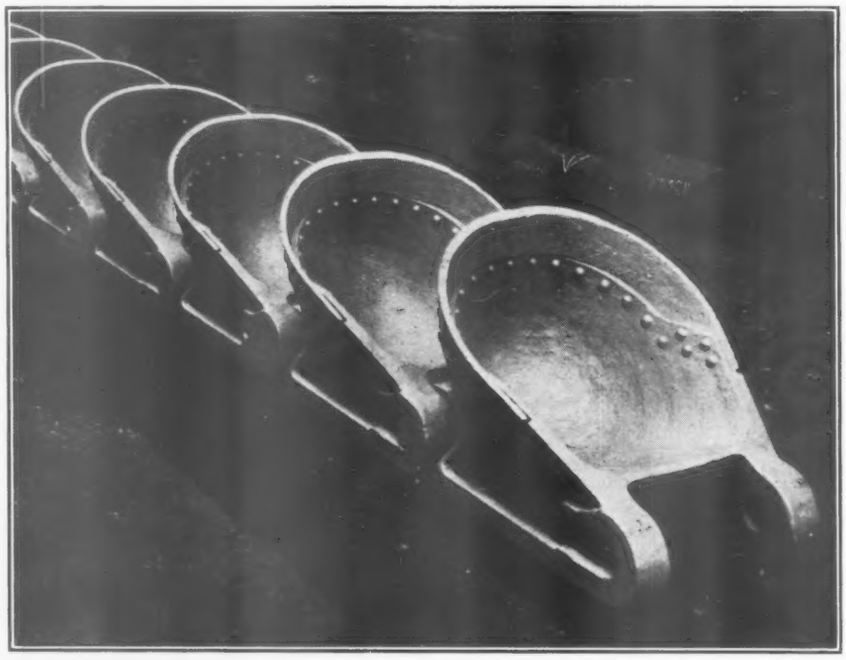

FIG. 2.—DREDGER BUCKETS IN AUSTENITIC-MANGANESE STEEL.

Heat-Resisting Steel Castings

The development of heat-resisting steels and their application to foundry production is another relatively recent development of the technology of alloy steels. In Table I the properties of the principal groups of heat-resisting steels suitable for castings have been correlated. The first three groups of analyses are all austenitic steels; they cannot be hardened by heat-treatment, and are put into service in the softened condition, which, it will be noted, is one of comparatively high tensile strength and extreme ductility and toughness.

A steel containing 26 per cent. chromium and 10 per cent. nickel is a critical composition, possessing good fluidity, and is eminently suitable for castings. In certain cases, however, it is desirable to have a higher nickel content in the region of 20 to 25 per cent. to assist the resistance of the steel to oxidation at temperatures in the region of 1,050 deg. C. Whilst there is little to choose as regards mechanical strength at ordinary temperatures between the different austenitic steels, addition of the element tungsten appreciably raises the strength at high temperatures, especially in the region of 700 to 900 deg. C.

Steels containing 30 per cent. chromium possess excellent resistance to scaling, but are usually brittle in the cold; whilst nickel-chromium alloys of the type 60 per cent. nickel, 20 per cent. chromium, 20 per cent. iron, though perhaps not, strictly speaking, steels at all, possess a maximum combination of strength and resistance to scaling at elevated temperatures.

Other Special Alloy Steel Castings

Finally, there is a miscellaneous collection of special foundry steels developed to fulfil specialised conditions of service. The first steel in Table I is a carbon steel of high magnetic permeability used for castings in electrical-generating machinery and for such as cast-steel crane magnets. This high permeability is obtained by keeping the elements carbon, silicon and manganese down to the lowest possible limits, but in so doing the greatest care must be exercised to make sure that the casting remains sound. The addition of molybdenum to ordinary carbon steel increases its strength at temperatures above the normal.

Comparing the 0.20 per cent. carbon steel containing molybdenum with straight 0.20 per cent. carbon steel, it will be seen that at ordinary temperatures it is only 25 per cent. stronger. Between 400 and 500 deg. C., however, its limiting creep stress is about double. Since the creep-stress is a true gauge to the behaviour of a material at high temperatures, the addition of molybdenum renders the steel just twice as strong under such conditions. Such a steel is invaluable for castings employed in high pressure steam plant of one type and another, such as, for instance, such castings as turbine casings and steam chests.

Simultaneous addition of ¼ to ½ per cent. molybdenum and 1½ per cent. manganese gives a steel which is characterised by extreme toughness and resistance to shock, although this property is not revealed in the test data shown in the table. Actually, it is best seen in service when castings of this analysis stand up even to the shocks and stresses met with in pile-driving equipment.

This brief survey may be completed by instancing two entirely different types of wear-resisting steel for the foundry. The carbon-chromium type, containing 0.50 to 0.75 per cent. carbon and about 1 per cent. chromium (molybdenum may also be added in the highest grades), attains considerable intrinsic hardness by heat-treatment. In fact, the higher grades reach 400 Brinell. The 13 per cent. manganese steel is, however, austenitic in character, which means that after heat-treatment it is relatively soft. On the other hand, when it is put into service under heavy crushing pressures, such as are withstood by a crusher jaw working on hard material, it "work-hardens" to a considerable extent. In other words, the more work there is put upon it, the greater is the hardness which it develops to resist the deformation.

In the most general terms, therefore, the carbon-chromium type of steel is used for castings employed in crushing and grinding plant, excavating and digging machinery, cement and brick-manufacturing equipment for these items subjected to wear without any heavy crushing or grinding pressures. But, when the conditions of service provide adequate work-hardening, the 13 per cent. manganese austenitic steel is to be preferred.

Such, in brief outline, is the development, up to the present day, of the application of alloy steels to the steel foundry. Their introduction has brought in their train a number of problems concerning fluidity of the steel, heterogeneity, contraction and porosity, refractoriness and mechanical strength of the sand; but such problems are yielding effectively before the patient work of our foundry technologists.

TABLE II.—*Industrial Applications of Various Types of Steel Castings.*

Class.	Analysis.	Typical analysis. C.	Si.	Mn.	Ni.	Cr.	W.	Mo.	Applications.
Carbon Steel ..	0.20 per cent. C	0.21	0.27	0.69	—	—	—	—	General structural and engineering mild steel castings.
,, ,, ..	0.30 per cent. C	0.32	0.24	0.73	—	—	—	—	Higher tensile general carbon steel castings.
,, ,, ..	0.40 per cent. C	0.39	0.26	0.64	—	—	—	—	General castings possessing wearing surfaces.
,, ,, ..	0.60 per cent. C	0.62	0.22	0.66	—	—	—	—	Cast steel die-blocks, anvils, hammer tups, cast steel hammer and press tools.
,, ,, ..	0.75 per cent. C	0.73	0.27	0.69	—	—	—	—	
Alloy Steel ..	1½ per cent. Mn { *a.* 0.25 per cent. C	0.23	0.31	1.41	—	—	—	—	Cast steel transmission gears and other parts requiring toughness. Excavator digger teeth and similar details requiring toughness and hardness, to resist a certain amount of abrasion.
	b. 0.45 per cent. C	0.43	0.24	1.36	—	—	—	—	
,, ,, ..	Ni-Cr	0.36	0.28	0.53	1.62	0.76	—	—	Cast steel gears, tractor excavator, crane, winch parts and other details requiring maximum strength and toughness.
,, ,, ..	Ni-Cr-Mo	0.32	0.23	0.72	1.87	0.78	—	0.38	
,, ,, ..	C-Cr	0.43	0.29	0.58	—	0.89	—	—	Specially suitable for cast steel gear blanks, owing to high tensile strength, toughness and good wear-resisting qualities.
Rustless Steel ..	14 per cent. Cr Stainless..	0.29	0.48	0.53	—	13.4	—	—	Cast steel hydraulic and steam plant details. Valves and other items submitted to mildly corrosive conditions.
,, ,, ..	18 per cent. Cr, 2 per cent. Ni, Stainless	0.17	0.31	0.57	1.7	17.9	—	—	Highly stressed casting submitted in service to more highly corrosive conditions.
Acid-Resisting Steel	18 per cent. Cr, 8 per cent. Ni	0.10	0.73	0.38	8.2	18.4	0.63	—	Essentially for castings required to resist highly corrosive conditions in chemical plant and for small decorative castings, such as taps, window fasteners, motor car handles, tramcar fittings.
Heat-Resisting Steel	26 per cent. Cr, 10 per cent. Ni	0.14	1.6	0.49	10.2	25.8	—	—	All classes of furnace details, such, for example, as stove enamelling racks and grids, heat-treatment trays, furnace dampers and furnace doors not submitted to any great stress at high temperatures.
Heat-Resisting Steel	20/25 per cent. Cr, 8/12 per cent. Ni, 3/4 per cent. W	0.14	1.76	0.43	11.4	23.9	3.2	—	Similar details, such as mechanical stoker parts, rabbles and mechanical pokers required to possess strength as well as resistance to scaling at high temperatures.
,, ,,	30 per cent. Cr	0.29	0.97	0.67	—	29.6	—	—	For any of the above items or others where resistance to scaling assumes greater importance than strength at elevated temperatures.
,, ,,	Nichrome (60 : 20 : 20) ..	0.97	0.84	1.12	63.8	22.1	—	—	For electric heater resistance wires, annealing and case-carburising boxes and other applications requiring maximum heat-resisting properties.
High Permeability Steel	Low C	0.09	0.32	0.10	—	—	—	—	Alternator stator castings, dynamo rotors, pole pieces, crane magnets and other castings for electrical machinery.
High Temperature Steel	Mo { *a.* 0.20 per cent. C	0.18	0.24	0.63	—	—	—	0.51	For high pressure steam plant; turbine casings, reciprocating engine, steam chests and other details subjected to stress at the temperature of superheated steam.
	b. 0.30 per cent. C	0.32	0.36	0.78	—	—	—	0.58	
Shock-Resisting Steel	Mn-Mo	0.25	0.26	1.43	—	—	—	0.54	Essentially to resist stresses and shocks in pile-driving equipment.
Wear-Resisting Steel	C-Cr	0.73	0.34	0.81	—	1.62	—	—	Ball, tube and rod mill grinding plates, impact mill hammers, wash-mill harrows and other castings submitted to wear by attrition.
,, ,,	Austenitic Mn	1.07	0.72	12.8	—	—	—	—	Jaw crusher plates, gyratory crusher cones and mantles, crushing rolls, ball, tube and rod mill plates and such applications when the wear takes place by crushing, hammering and pounding.

TABLE III.—*Physical Data of Foundry Steels.*

Class.	Analysis.	Heat-treatment.	Contraction allowance.	Freezing range, liquidus/solidus.	Distinctive properties.
Carbon Steel ..	0.20 per cent. C	Annealed 900 deg. C.	$\frac{3}{16}$ in. per ft.	1,525/1,490 deg. C.	Dead mild steel; tough and ductile.
,, ,, ..	0.30 per cent. C	Annealed 890 deg. C.	$\frac{3}{16}$ in. per ft.	1,520/1,460 deg. C.	Higher tensile strength.
,, ,, ..	0.40 per cent. C	Annealed 860 deg. C.	$\frac{3}{16}$ in. per ft.	1,510/1,430 deg. C.	Greater hardness and resistance to surface wear.
,, ,, ..	0.60 per cent. C	Annealed 840 deg. C.	$\frac{3}{16}$ in. per ft.	1,500/1,390 deg. C.	Considerable surface hardness, but not much toughness.
,, ,, ..	0.75 per cent. C	Annealed 810 deg. C.	$\frac{3}{16}$ in. per ft.	1,490/1,360 deg. C.	
Alloy Steel ..	1½ per cent. Mn { 0.25 per cent. C	Annealed 920 deg. C.	$\frac{3}{16}$ in./$\frac{7}{32}$ in. per ft.	1,510/1,450 deg. C.	Increased tensile strength, hardness and toughness.
	1½ per cent. Mn { 0.45 per cent. C	Annealed 900 deg. C. or O.H. 870 deg., T. 600/650 deg. C.	$\frac{3}{16}$ in./$\frac{7}{32}$ in. per ft.	1,500/1,400 deg. C.	
,, ,, ..	Ni-Cr	Annealed 900 deg. C. O.H. 870 deg., T. 550/650 deg. C.	$\frac{3}{16}$ in. per ft.	1,510/1,450 deg. C.	Medium high tensile strength and great toughness.
,, ,, ..	Ni-Cr-Mo	Annealed 900 deg., A.H. 870 deg., T. 550/650 deg. C.	$\frac{3}{16}$ in. per ft.	1,500/1,420 deg. C.	High tensile strength and maximum toughness.
,, ,, ..	C-Cr	Annealed 900 deg., O.H. 870 deg., T. 550/650 deg. C.	$\frac{3}{16}$ in. per ft.	1,510/1,450 deg. C.	Medium high tensile strength and good resistance to surface wear.
Rustless Steel ..	14 per cent. Cr Stainless	O.H.960/980 deg., T.700/750 deg. C.	$\frac{1}{4}$ in. per ft.	1,500/1,430 deg. C.	Resistance to rust and mild corrosion.
,, ,,	18 per cent. Cr. 2 per cent. Ni Stainless (S.80 type)	O.H.960/980 deg., T.500/550 deg. C.	$\frac{1}{4}$ in. per ft.	1,500/1,420 deg. C.	High tensile strength and improved corrosion-resistance.
Acid-Resisting Steel	18 per cent. Cr. 8 per cent. Ni, Stainless ("Staybrite" type)	A.C. or W.Q. 1,050/1,150 deg. C.	$\frac{9}{32}$ in./$\frac{5}{16}$ in. per ft.	1,470/1,400 deg. C.	Resistance to acid attack and other severe forms of corrosion (non-magnetic and high coefficient of expansion.)
Heat-Resisting Steel	26 per cent. Cr, 10 per cent. Ni	A.C. 1,050 deg. C.	$\frac{9}{32}$ in./$\frac{5}{16}$ in. per ft.	1,450/1,390 deg. C.	Excellent resistance to scaling and fair strength at high temperatures in the region of 1,000/1,050 deg. C. (non-magnetic and high coefficient of expansion).
Heat-Resisting Steel	20/25 per cent. Cr, 8/12 per cent. Ni, 3/4 per cent. W	A.C. 1,050 deg. C.	$\frac{9}{32}$ in./$\frac{5}{16}$ in. per ft.	1,450/1,390 deg. C.	Excellent resistance to scaling and great strength at elevated temperatures in the region of 1,000/1,050 deg. C. (non-magnetic and high coefficient of expansion).
Heat-Resisting Steel	30 per cent. Cr	O.H. 1,050 deg., T. 600/700 deg. C.	$\frac{1}{4}$ in. per ft.	1,450/1,380 deg. C.	Excellent resistance to scaling but brittle in in the cold.
,, ,,	Nichrome Alloys ..	A.C. 1,000 deg. C.	$\frac{1}{4}$ in. per ft.	1,300/1,250 deg. C.	Excellent resistance to scaling and great strength at high temperatures.
High Permeability Steel	Low C	Annealed 900 deg. C.	$\frac{3}{16}$ in. per ft.	1,530/1,490 deg. C.	High magnetic permeability
High Temperature Steel	Mo { 0.20 per cent. C ..	Annealed 900 deg., A.H. 870 deg., T. 650 deg. C.	$\frac{7}{32}$ in. per ft.	1,520/1,470 deg. C.	Increased strength at elevated temperatures in the region of 400/500 deg. C.
	Mo { 0.30 per cent. C ..	Annealed 900 deg., A.H. 870 deg., T. 650 deg. C.	$\frac{7}{32}$ in. per ft.	1,520/1,440 deg. C.	
Shock-Resisting Steel	Mn-Mo	Annealed 900 deg., A.H. 870 deg., T. 650 deg. C.	$\frac{1}{4}$ in. per ft.	1,500/1,430 deg. C.	Excellent toughness and resistance to shock.
Wear-Resisting Steel	C-Cr	Annealed 920 deg., O.H. or A.H. 870/900 deg., T. 550/650 deg. C.	$\frac{3}{16}$ in. per ft.	1,490/1,340 deg. C.	Considerable intrinsic hardness and resistance to wear by attrition.
,, ,,	Austenitic, 13 per cent. Mn	W.Q. 1,000 deg. C.	$\frac{5}{16}$ in. per ft.	1,400/1,350 deg. C.	Great toughness and resistance to wear by crushing, hammering and pounding (non-magnetic and high coefficient of expansion).

Foundry technique has adapted itself to the use of this wide variety of alloy steels; and to-day carbon and alloy-steel castings, whilst not displacing other forms of steel, nevertheless occupy an essential position in every branch of engineering.

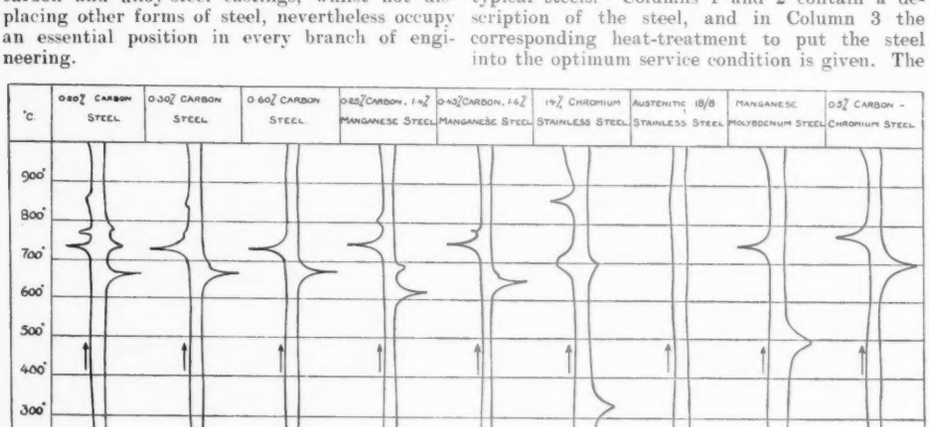

FIG. 4.—HEATING AND COOLING CURVES OF VARIOUS FOUNDRY STEELS.

In Table II is given a summary of the typical applications of these various steels, together with an analysis typical of each case for the purpose of correlation with other data which is subsequently given.

Essential Data Concerning Foundry Steels

In Table III data are given concerning these typical steels. Columns 1 and 2 contain a description of the steel, and in Column 3 the corresponding heat-treatment to put the steel into the optimum service condition is given. The fourth column gives the allowance which should be made for the contraction of the steel solidification, and it should be noted that this varies with the change in analysis; whilst in the fifth column the author has made an attempt to correlate the information extant concerning the freezing ranges of the various steels. The higher figure represents the liquidus, or the temperature at which solidification commences; whilst the lower limit, on the whole of less practical importance, is the solidus. The solidus should not, however, be lightly overlooked, because it is of value in determining at what temperature a large casting should be stripped. Finally, in the last column the essential properties of each type of steel are listed.

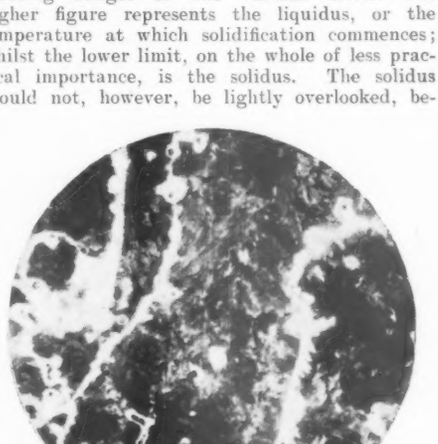

FIG. 5.—0.40 PER CENT. CARBON STEEL. AS CAST. × 200.

(To be concluded.)

Refractories for Foundry Use*

By W. J. REES, M.Sc. (Head of Refractories Department, University of Sheffield)

Looking at the question quite simply, two general methods of lining the cupola must be recognised:—(1) The use of a brick lining and (2) the use of a rammed lining, some granular, plastic or semi-plastic material being rammed around a former. Consideration of the general characteristics of both types of lining, as well as the types of material used for maintenance purposes, such as patching material, will show that they all have individual characteristics.

In considering first of all the firebrick type of lining, and it must be remembered that even when the cupola is rammed with some type of lining it may have a backing of firebricks, there are a number of factors which are important in connection with their durability. Consider, for example, the general chemical composition of the bricks. Fig. 1 shows the alumina-silica fusion curve, and on it is marked the fusion point of representative firebricks. Particular attention is drawn to the general slope of the curve; as the proportion of alumina falls so the refractory value also falls. In other words, the higher the alumina content, the higher the melting point. Clays of comparatively low refractory value or fusion point, however, may have other characteristics which will render them of value for particular purposes.

In the modern cupola, very high temperatures are reached and a good deal of mechanical stress is prevalent, due to charging, slag action, etc., and it is desirable, therefore, to select a brick which will resist all these conditions as well as possible. It is quite evident from Fig 1 that from the point of view of resistance to high temperature the brick should be either high in alumina or high in silica. Unfortunately, the silica brick is not particularly suitable for the lining of the cupola because it will not satisfactorily resist very rapid heating or cooling. The cupola is of necessity heated up quickly, but quick heating is not desirable for the ordinary type of silica brick. A silica brick might be developed eventually which would withstand these rapid changes in temperature, but the present ordinary type of silica brick cannot be satisfactorily used in the cupola because of this lack of resistance to rapid heating and cooling. So from the point of view of refractoriness, the high-alumina types of firebrick must be considered; most firebrick manufacturers have such bricks in their range of products.

Cupola bricks, however, have to resist not only high temperature, but abrasion and mechanical stresses generally, and the question to be considered is whether the brick resistant to high temperature will be resistant also to these stresses. One characteristic of bricks made from fireclay is that they tend to lose some of their mechanical strength when raised to high temperatures, and the general trend is for this "refractoriness under load" to decrease slightly with increase in the alumina content of the fireclay.

Fig. 2 shows the results of "under-load" tests on firebricks used in cupolas, the load being 50 lbs. per sq. in. Marked differences are seen both in the temperature at which deformation commences and the rate at which it progresses. A general consideration of the mechanism of subsidence under load has shown that attention should be directed specially to the range A-B in Fig. 3. Below the temperature at which marked flattening of the curve becomes noticeable, point A, deformation occurring under loads occurring in cupola practice will be negligible. At temperatures higher than that corresponding to point B on the curve, severe deformation may take place under very small loads. Within the range A-B, the rate and extent of the deformation will depend on the actual temperature and load; marked acceleration in the rate of deformation will occur with comparatively small increases in temperature. The iron-oxide content of a brick may have an important influence on its ability to withstand pressure at high temperatures in a reducing atmosphere.

The pressure on bricks in the cupola may be developed in three ways:—(*a*) From the direct weight of the structure; (*b*) from pressure developed by thermal expansion, and (*c*) from the weight of the charge. It is quite possible for these pressures to reach as much as 30 to 40 lbs. per sq. in. The desirable brick for cupola service, therefore, will be one which has a wide deformation range.

MR. W. J. REES.

Glaze and Abrasion Resistance

Bricks made from clay having compositions in the region of comparatively low refractory value have the important characteristic of readily becoming skin-glazed, and become, in consequence, highly resistant to abrasion. Bricks in this category develop a "skin" when subjected to a temperature of, say, 1,400 deg. C., whereas bricks of a higher refractoriness would not.

Another important point is that of volume constancy during service. The general tendency of fireclays is to contract when raised to a high temperature. On the other hand, the tendency of silica is to expand. It is possible to produce a mixture of fireclay and silica in which the contraction of the fireclay more or less balances the expansion of the silica. Bricks of this "semi-silica" type are of value therefore under some conditions of service, despite their comparatively low refractory value. With all ordinary types of firebrick, the brick should be so thoroughly burned by its maker as to be free from permanent volume changes during service. Any marked "after-contraction" of bricks in the cupola will tend to reduce their durability as it will lead to opening of joints with consequent localised slag attack.

Black Cores in Bricks

Generally speaking, bricks of the high alumina type give much better service in a cupola, when the clay naturally contains just enough fluxing impurities to introduce vitrification without materially lowering the refractoriness. This vitrification gives mechanical strength to resist the severe abrasive conditions in the cupola. Uniform and thorough burning may be important from another viewpoint. Defective burning of bricks made from a carbonaceous fireclay may leave a black heart or core in the brick. The disadvantage of a black core is that it may lead to internal slagging of the brick. The clay contains 1-3 per cent. of iron oxide, and when this reacts with the clay under reducing conditions, the tendency is for the formation of ferrous silicate, which has both a low melting point and low viscosity, and permeates through the brick, with serious detriment to its service.

Carbonaceous matter left in the core of the brick may produce reducing conditions inside the brick and so lead to reaction between the iron impurities and the rest of the brick, followed by slagging and rapid destruction of the brick. Too much stress cannot be laid upon the importance of careful burning. The general texture of the brick must be uniform and moderately fine to withstand abrasion.

Corrosion Resistance

Cupola bricks have to withstand corrosion by slags frequently high in both lime and iron oxide. The well-made and well-burnt fire-brick of the high alumina type will show more resistance to such slags than the siliceous type. It is useful to test the resistance of any particular brick to corrosion by the slag produced in any particular cupola. One method of doing this is to bore a hole in a brick and fill it with slag, subsequently heating to cupola temperature. After prolonged exposure the brick can be broken across the hole and examined for slag penetration. This method of test has the effect, however, of destroying the skin of the brick which becauses of its density is more resistant to corrosion than the interior of the brick. A better method of test which retains this skin of the brick is to cement to the surface of the brick a ring made from a refractory clay, fill it with slag, and see what penetration takes place after heating for some time to the cupola temperature. Such tests give very useful data.

Close Jointing

It is very desirable that the cupola brick shall be so well made that it can be closely jointed. Close jointing always promotes durability and avoids the penetration of the joints by slag. Corrosion almost invariably starts at the joints, and the wider the joints, the quicker is the corrosion. Slag collects in the small "pockets," resulting in a rapid development of holes between the bricks.

Special attention should be given to the quality of the jointing cement, or mortar. It is little use taking a great deal of care in the selection of the bricks if an equal amount of care is not taken in the selection of the jointing cement. It might almost be suggested that even more care should be taken in the selection of the jointing cement. Jointing cements are now available which are even more refractory than the high-grade fireclay from which the bricks were made. Contraction in the jointing material may tend to rapid corrosion through opening of joints. The most satisfactory fireclay jointing cement is that which contains *a large proportion* of already burnt material, or grog, as this will show a much smaller contraction than a "neat" fireclay cement. The cement should also be very finely ground so as to keep the joints as thin as possible.

It is desirable to avoid bricks containing free-iron oxide, especially in a segregated form.

The cupola atmosphere may contain a high proportion of carbon monoxide, and when this comes in contact with free-iron oxide in the

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bricks there is a tendency for the carbon monoxide to dissociate and carbon to be deposited. This may take place to such an extent as to cause actual disintegration of the firebrick. It will be seen, therefore, how important it is to avoid segregation of the iron impurities in the brick if this state of affairs is to be side-tracked.

Rammed Linings

There are a number of factors which are of great importance when considering the use of rammed linings. To give satisfactory behaviour in the cupola it is evident that the material must develop sufficient mechanical strength *on drying and heating* to resist the stresses set up.

When the rammed material is heated it must vitrify enough to produce mechanical strength and must have satisfactory volume stability, as excessive shrinkage may lead to the opening of cracks.

Most of the mixtures which are used for ramming cupolas are in the highly-siliceous end of the curve (see Fig. 1), and will contain more than 90 per cent. of silica. They should not be in the region of, say, 88 to 90 per cent. silica, because that is the region of the lowest melting point. They should either be 1 to 3 per cent. higher, or 5 to 10 per cent. lower and not near the eutectic point. The presence of fluxing impurities in the material tends to move the eutectic to the right (Fig. 1).

In general practice the mixtures of this type are made from either a naturally-occurring highly-siliceous material, or from a mixture of a highly-siliceous rock, with just enough clay to give it the necessary workability, but whether a natural material or a synthetic mixture is used, it is desirable to keep well clear of the eutectic composition.

FIG. 1.—MELTING-POINT CURVE OF ALUMINA-SILICA MIXTURES.

Fortunately there are excellent materials available which will give ramming mixtures having the correct characteristics, although most of the natural materials may not be suitable for direct use without some preparation. With synthetic mixtures more control is possible, but a difficulty with such mixtures is to obtain such perfect distribution of the clay over the silica grains as is found in some natural deposits. It is particularly important that the producer working a naturally-bonded deposit should take great care to keep to a sample, and avoid variations in bond content or texture. It is possible to improve the characteristics of some of these naturally-bonded materials by making additions to them of crushed silica rock or high-silica sand.

Patching Materials

Patching materials, used for cupola lining maintenance, must have such characteristics as will enable them to "stay put," or develop adhesion, when heated. The wet patching material is forced into position, the worn place made good, and, almost immediately, the cupola heated. The following cycle takes place:—

(1) The water in the material driven off; (2) the combined water in the clay driven off and (3) sufficient vitrification is induced to make that patch adhere to the rest of the lining. It will be seen, therefore, that about as severe a condition as one can imagine is set up, so a material has to be selected that will withstand those severe strains, which is no easy matter. Such materials must be used always with only just enough water to give the necessary characteristics for patching. The patching material must not be over-watered, otherwise cracks will tend to develop, resulting in the penetration of slags.

Materials of this kind are generally made by mixing crushed high-silica rock—such as Sheffield ganister—with a refractory plastic clay. The very best type of silica rock should be used.

The materials known as "Cupola Ganister" are very mixed both in composition and texture, and whilst the producers of these materials in the Sheffield area have made great progress in standardising this product, such standardisation is made difficult by the great variation in cupola conditions. It is by no means unusual for a ganister mixture which gives good service in one cupola to be totally unsatisfactory in another working under conditions which do not appear to be very dissimilar. It seems evident therefore that the method of using the ganister has a definite influence on its durability. Incidentally, a ganister patching would often last better if more care were taken in the cleaning and removal of clay from the worn place in the cupola.

It is not an easy matter to produce a material which will withstand the strains which are set up in the normal usage of cupola ganister. The water content should be only just sufficient to give the necessary workability to the material, as over-wetness whilst it may make patching easier will reduce the mechanical strength of the patch and lead to cracking and consequent slag penetration, despite the expansion which takes place when the silica rock becomes hot. As a basis for these materials it is desirable to use a silica rock, such as the typical Sheffield ganister, which crushes into angular fragments. Rounded fragments tend to slip over each other, and so lead to weakness, whilst angular fragments tend to interlock and so promote strength. It is important that the matrix of the cupola ganister (*i.e.*, the finer fragments of silica plus the bond clay) should have a composition which is not too near the eutectic (Fig. 1), as this will lead to rapid fusion and possible dripping or running out of the matrix and a "honeycomb" type of corrosion or wear. A useful method for testing a cupola ganister is to slowly heat briquettes (say 4 in. by 1½ in. by 1 in.) made from an average sample to 1,500 deg. C. and hold them at that temperature for 5 or 6 hrs. A good material will show little or no shrinkage, and will be well vitrified with only slight deformation of shape of the test-piece and no "running-out" of the matrix.

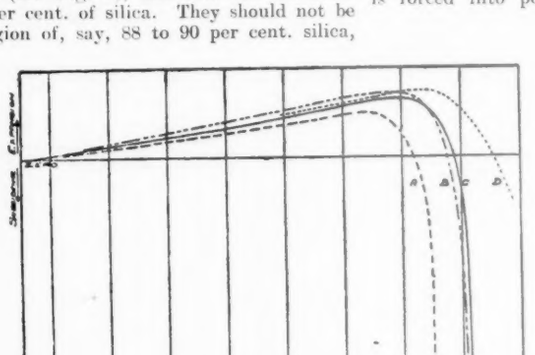


FIG. 2.—UNDER-LOAD CURVE OF CUPOLA BRICKS.

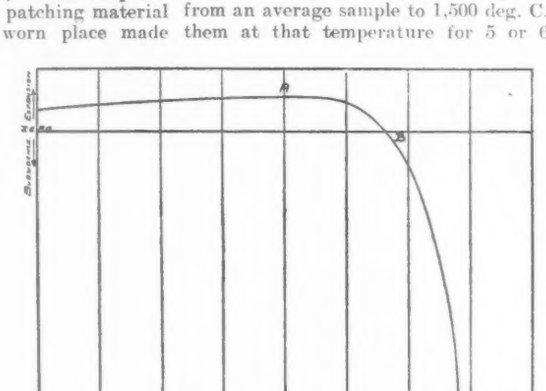


FIG. 3.—UNDER-LOAD CURVE OF FIREBRICK.

Effect of Temperature on Metal Properties

The American Society for Testing Materials and the American Society of Mechanical Engineers have published jointly a bound volume "Symposium on effect of temperature on the properties of metals," containing the Papers presented at the joint meeting of the two societies held at Chicago on June 23, 1931.

Suggestions for Research on Steel Castings*

By Professor J. H. ANDREW, D.Sc.

(Dean of the Faculty of Metallurgy, University of Sheffield)

It is surprising to find on reviewing the literature how small is the amount of academic research and theoretical consideration given to steel castings, as compared with the work carried out on steel ingots and forged material. A casting is different from a forging with respect to its having undergone no mechanical work, and, as often as not, no heat-treatment. Further, in a casting the mould is usually of sand, excepting in the case of permanent moulds.

Perhaps the greatest trouble experienced with castings is with respect to contraction cavities, and blowholes; the former being largely localised where changes in section occur; whilst the latter source of trouble may arise either through gas in the metal or in the sand. Further, blowholes are necessarily accompanied by segregation, a fact that is not always recognised. With regard to contraction cavities, the writer is convinced that the view of the late Mr. J. H. S. Dickenson, that each and every section of a casting must be regarded as a separate ingot, is correct. This being so, it is essential to provide fluid metal sufficient to supply each particular section as contraction is proceeding.

Research carried out with a view to systematising the method of feeding and arrangement of heads might well be undertaken, for there is no reason whatsoever why, if the conditions advocated could be complied with, and given good metal and moulding, sound casting should not always result. Such a suggestion will naturally call for the comment, that many thousands of different types of castings are made every day in the foundry. This is true, but even so the author is convinced that much could be done by experimental research founded on logical conceptions to eradicate the troubles that arise through contraction cavities.

A New Alloy Sought

The discovery of an element that when added to steel would reduce the fluid-solid contraction would be invaluable, and this might well be made the subject for investigation. As yet there is very little data on this question, or how such contraction is affected by added elements. Heated moulds supply no solution, for whatever temperature a mould be heated to, the steel will solidify at the same temperature or over the same range of temperature irrespective of the temperature of the mould. The rate of cooling of a liquid or of a solid can be reduced, but the control of the rate of solidification where the range is but narrow is a physical impossibility.

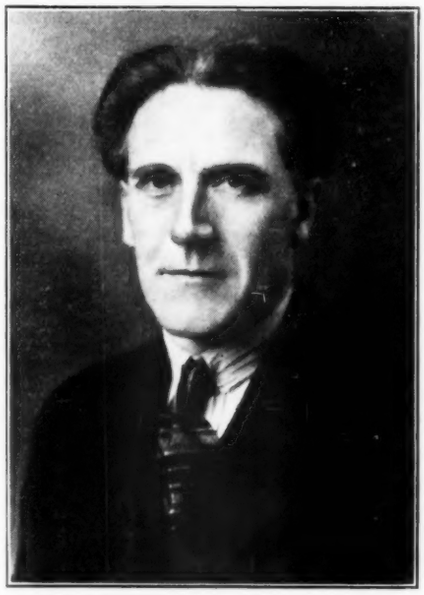
With regard to the formation of blowholes, in so far as gas from the metal is concerned, this could be obviated by the addition of the correct amount of aluminium. Aluminium, however, is known to make the running sluggish, and to give rise to deeper pipe cavities. A high temperature of casting coupled with feeder heads arranged correctly might, however, obviate this defect.

Oxygen-Free Steel

It is, however, an open question as to whether an oxygen-free steel is desirable from the standpoint of its strength. Recent research undertaken in the writer's laboratories has indicated that the tensile strength of steel drops very markedly when all the oxygen is removed. Provided the oxygen remains dissolved in the steel it may possibly be an asset rather than otherwise. Very interesting and profitable investigations might well be conducted on the lines just indicated.

Facing Sand

Blowholes arising from the mould, in the case of green-sand casting, must depend largely upon the porosity of the sand. The usual practice of coating the mould with a fine carbonaceous facing sand requires looking into. In the first place, carbonaceous gases along with hydrogen are generated at the metal-sand interface. If the sand be insufficiently porous, or the venting insufficiently good, gas will penetrate the metal with the formation of blowholes. The author many years ago was instrumental in introducing



PROFESSOR J. H. ANDREW.

into a foundry making large steel castings, a facing sand entirely free from carbon, and the results were so good that the practice was adopted. Research on facing sands, with particular reference to the composition of such sand, would seem to be well worthy of undertaking.

A carbon steel containing less than 0.7 per cent. of carbon begins to solidify with the deposition of almost carbonless iron, the carbon-rich material not solidifying until later. Thus, every steel casting is heterogeneous even at temperatures just below the solidification temperature, and will remain so down to atmospheric temperature. It is, therefore, very necessary to normalise a steel casting, not only to remove casting stresses, but to bring about a greater uniformity of structure.

A correctly heat-treated casting may give tests equal to the same material in a forged condition. Thus, it is possible that castings which can be heat-treated might readily replace the more costly forged material.

Alloy Steel Castings

Alloy steel castings might, under certain conditions, successfully be oil-hardened and tempered, whilst there seems no reason whatsoever why air-hardening steels in which an air-hardening is given subsequent to casting should not come into more general use. An alloy steel having a normal critical point below 400 deg. C. could be safely heat-treated, for the critical change is at a temperature below that at which steels possess good tensile properties, and the tendency to fracture would seem to be very remote.

The particular atmosphere in which a steel is melted is also a matter deserving investigation. It is quite possible that the atmosphere in which the molten steel is submerged may have an appreciable effect not only on the soundness, but also on the mechanical strength of the resulting castings. It is, for instance, often alleged that the hardness of a quenched steel depends upon the type of furnace in which it is heated for hardening, oil, gas, coal, coke or electric, and there would appear to be some truth in this thought.

The effect of casting temperature upon fluidity is at present receiving considerable attention. There is some reason for the view that the oxygen content of the steel is the controlling influence, so that to make research on fluidity of the greatest value, the oxygen content of the metal should be known, that is to say, should be determined by careful analysis.

In fluidity testing it is essential that all tests should be carried out under exactly the same conditions, and these conditions are by no means easy to comply with. For instance, the metal should be run into the fluidity test mould, at the same rate, from the same initial height, and obviously the same volume of metal must be used. These and other factors are necessary to take account of if absolute results are sought.

Generally speaking, a very considerable amount of valuable research awaits the investigator who has at his service an equipment capable of dealing with small weights of metal, up to half a ton, the necessary means of providing suitable moulds and accurate pyrometers. It is only by carrying out such practical tests in a suitable laboratory, which is in no way concerned with output, or with the soundness of products, but one in which every casting scrapped is in the nature of valuable research, that consistent progress can be hoped for, and much remains to be learned.

* A Paper read before the Annual Meeting of the Institute of British Foundrymen at Sheffield, July 2 to 5, 1935.

Iron and Steel Output in June

The British Iron and Steel Federation reports that there were 97 furnaces in blast at the end of June. The production of pig-iron in June amounted to 529,300 tons, compared with 558,900 tons in May. The month's production included 106,000 tons of hematite, 295,300 tons of basic, 104,700 tons of foundry, and 10,000 tons of forge pig-iron. The output of steel ingots and castings amounted to 770,000 tons in June, as against 853,300 tons in May.

Works Holidays

Work was stopped at Port Glasgow, Greenock and Falkirk for the annual holidays with a much greater degree of satisfaction than has been felt for several years, as trade has been improved and employment more regular since the beginning of the year. This is specially the case in the Falkirk district, where the holiday follows on a spell of improved business in the light-castings industry—the staple local industry. An official of the Ironfounding Workers' Association has stated that since the commencement of the present year the number of members of all grades has remained steadily at a very low figure. He emphasised the fact that at the present time, despite the frequent assertions that the trade of the district is steadily going south, there are more men in regular employment in the foundries in Falkirk and district than there were 16 years ago. He regards the outlook as distinctly promising, and holds the opinion that Falkirk will command its full share of reviving trade for at least ten years to come. In the Motherwell district the Fair holidays at the Dalzell steelworks of Messrs. Colvilles, Limited, have been curtailed to one week instead of the usual fortnight.

XUM

Factories and Workshops

CHIEF INSPECTOR'S ANNUAL REPORT

The Annual Report* of the Chief Inspector of Factories and Workshops for 1934 includes the usual chapters dealing with various phases of industrial activity and the accident or sickness causation associated therewith.

Lighting

On the subject of lighting, it is pointed out in the General Report that, although improvements, including numerous new installations, have been noted during the past year, advance in lighting efficiency generally has not kept step with progress in those factory conditions, *e.g.*, fencing and ventilation, in respect of which there are legal requirements. In certain trades in particular, inefficient lighting remains prevalent. Trade revival in the ironfounding industry has brought improvement only in a minority of cases, and most foundries are still poorly lit, though, where improvement has occurred, very high standards have been reached. Factories in which the lighting needs of each worker are individually considered (a valuable principle) have been noted, together with several ingenious devices for illuminating unusual processes.

While much still remains to be done among the Sheffield trades, disclosure by the inquiry made during the winters of 1932-33 and 1933-34 of the unsatisfactory and wasteful conditions has stimulated local interest, and steady improvement has been apparent. Many of the steelworks and larger factories have modernised their installations, and numerous smaller concerns have introduced better and more suitable lighting fittings. Application of low-voltage points for local lighting is increasing. They are especially suited to withstand vibration, and installations have been successfully completed at various file-cutting, drill-shaping and other machines.

In a different category are several new installations of the latest types of mercury-vapour lamps. Such a system, automatically controlled, was recently installed in a large steelworks and provides a minimum floor illumination of 8-ft. candles. In two large foundries similar installations have proved successful. With an initial light output of 16,000 lumens, the 430-watt points, situated at 26 ft. above ground level, illuminate an average floor area of 625 sq. ft. These lamps are claimed to be particularly suitable for foundry illumination in view of the economy of consumption in proportion to light output. Both glare and shadow are largely eliminated, and outline and detail in the dark sand is said to be much more clearly defined than by ordinary methods of lighting. Similar units have also been introduced into the fettling shops.

Accidents

There was a marked increase in the total number of accidents reported during 1934, the number having increased from 113,260 to 136,858 and the fatalities from 688 to 785. The Report for the previous year showed a similar but smaller increase, but it is noteworthy that in 1934 the increase in reported accidents applies almost universally to every part of the country. This is undoubtedly due mainly to a more general expansion in industrial activity and to the greater number of workers employed. As mentioned in last year's Report, however, it must be remembered that the re-employment of many workers after a long spell of unemployment involves a greater accident risk among such workers until such time as they again become accustomed to working activities and also recover their work-fit physical and alert mental conditions.

The total number of accidents due to transmission machinery was 1,143 as compared with 1,066 in the previous year. There were 38 fatalities reported as compared with 35 in the previous year. Of the fatal accidents, 21 occurred at revolving shafts, while 17 were due to driving belts, ropes, pulleys and gearing. Of the non-fatal accidents reported, 143 occurred at shafting and 962 at driving belts, ropes, etc. Shafting accidents are usually of a very serious nature and in many of the non-fatal cases the injuries are such as to incapacitate the worker either wholly or partially for life. This class of accident is still far too numerous, and it has been found necessary to institute legal proceedings in many cases against occupiers of factories. Though there is little evidence in the Inspectors' reports of the more general adoption of belt hangers or perches, or of mechanical belt-mounting appliances, the use of suitable belt-mounting poles seems to be increasing to some extent. Defective belt-shifting gear has again been responsible for a number of serious accidents through machines, ostensibly at rest with the driving belt moved on to the loose pulley, suddenly starting again owing to the belt creeping partly on to the driving pulley.

Accidents due to the use of overhead travelling cranes, although not excessive in number, are usually severe, *e.g.*, in 1931 there were 39 accidents reported in this category, of which three were fatal, and in 1932 the corresponding numbers were 47 and five, respectively. As the majority of these accidents had occurred in large engineering works and iron and steel works, the matter was discussed with representatives of the Employers' Associations concerned, as a result of which the Associations agreed to direct the attention of member firms to the necessity for greater attention to safety measures. The result so far is satisfactory, as only 32 accidents, including one fatal, were reported during 1934. The reports, however, show that, with proper precautions, these accidents could be further reduced, and the matter is again to be discussed with the Associations with that object.

Health

Dust.—Fifty-seven deaths from silicosis and 50 from silicosis with tuberculosis have come to the notice of the Department during the year, together with six deaths from asbestosis and eight from asbestosis with tuberculosis. With regard to silicosis, it is of some significance that the average age at death and the figures for the duration of employment in the various industries remain very constant from year to year. Apart from the manufacture of scouring powders, from which industry one death is to be recorded, sandblasting, causing four deaths, continues to be the process in which silicosis with and without tuberculosis develops within the shortest period of employment. The Senior Medical Inspector, in his report for 1933, discussed the risk attendant upon this process, and emphasised the desirability of the substitution of a non-siliceous abrasive. Considerable advance has been made, but he is not satisfied that this has gone as far as it might have done. To substitute steel grit or shot and to obtain a satisfactory result requires in some instances considerable thought and time, both as regards the grade of grit or shot and pressures to be used; further, in some cases a change of nozzle is found necessary. To turn the metallic abrasive down after a trial with one or two grades, using the same pressure and the same apparatus, as has been done in several instances, shows a lack of appreciation of the risk of sandblasting.

Fumes and Gases

Carbon Monoxide.—There is a substantial increase in the number of cases of gassing due to blast-furnace gas, which is difficult to account for except by the number of furnaces which have been restarted. There can be no doubt that very special precautions need to be taken on the occasions when furnaces are restarted after standing or after repair. The view held by Mr. McNair (H.M. Engineering Inspector), though not generally accepted, that gas can percolate through a brick wall, was amply confirmed in a case which occurred at an iron and steel works. Subsequent experiments showed that gas can percolate through even a wall of 14-in. thickness. In order to prevent percolation, the wall needs to be thoroughly tarred and the tarring to be repeated if the wall has been allowed to cool.

One fatality was unusual, in that the deceased, a crane driver, brought his crane over an annealing furnace, and was found unconscious later. Medical evidence at the inquest suggested that in addition to carbon monoxide, carbon dioxide played a part in the causation of the fatality.

Sulphuretted Hydrogen.—Only two cases of gassing by hydrogen sulphide occurred during the year, one being due to an escape from a tar still at an iron and steel works, and the other to the emptying of ferrous-oxide absorption boxes used in the manufacture of sulphate of ammonia in a fertiliser works.

* H.M. Stationery Office, Adastral House, Kingsway, London, W.C.2. (Price 2s. net.)

Fusion Welds with Austenitic Materials

Discussing the structure of bonds obtained in fusion welding with austenitic materials, F. RAPATZ and W. HUMMITZSCH, in the "Archiv für das Eisenhüttenwesen," point out that austenitic materials have the advantage of giving machinable welds which are practically unaffected by heating and cooling. These advantages are particularly useful with hardenable parent material. At the bond between the material and the weld, martensite is found to be in preponderance, while in some cases, where the weld and the parent material have a low carbon content, ferrite is also observed. When the carbon content increases in the parent material the austenite of the weld penetrates the former along the grain boundaries. Nickel austenite was found to produce a tougher joint than manganese austenite, probably because nickel having a lower diffusion velocity forms thinner martensite transition layers than manganese. A disadvantage of manganese is, moreover, the greater liability to overheating of manganese martensite. Chromium and molybdenum facilitate welding, but have a much less effect on the weld structure than either nickel or manganese. In welds with manganese steel hardening and shrinkage cracks readily occur, the former as a result of the tendency of overheating of manganese martensite and shrinkage cracks as a result of the greater thermal expansion of austenitic manganese steels. Low carbon content in both the parent material and the weld favours the production of a machinable joint, although with nickel austenite a higher carbon content can be employed in both the weld and parent materials. The authors have found from the series of tests made that austenitic material, especially nickel and chrome-nickel steels, give a satisfactory bond with wear-resistant steels containing 12 per cent. of manganese and with pearlitic steels, even with higher carbon contents.

ALLIED IRONFOUNDERS, LIMITED, have made an offer to purchase the whole of the issued share capital of Aga Heat, Limited (which amounts to £175,000), on the basis of an exchange of shares.

Strickle Moulding of Large Castings

By H. FABRE (Managing Director) and H. DUBOIS (Foundry Manager) of the Etablissements Bracq-Laurent, at Achicourt (Pas-de-Calais)

(*Concluded from page* 36.)

Rectilineal or Curvilineal Strickling (Moulding of a Pipe-Bend, weight 1,000 kg.)

Patternmaking.—In making the mould (Fig. 8) the patternmaker prepares:—(*a*) A templet A, the surface of which imparts the shape to the bend and determines its external dimensions, and (*b*) a strickle B cut to the external diameter of the bend, and the height of which, above the axis, is equal to the thickness of the boards of the templet A.

Moulding.—A half-portion of the bottom box is rammed, while marking the position of the lower half-flanges. The outline of the casting is traced with the aid of the templet, before ramming the top box. The lower tracing is marked on the top joint. The upper portion having been lifted and turned over, strickling is then effected with the scraper B, in accordance with the tracing, on the seating of the half-flanges, with the aid of the templet.

Coring.—Two half-cores are strickled on a bottom plate by means of the templet with which the mould has been strickled. The scraper has a slot *e*, the length of which is equal to the thickness of the bend. After stove-drying, the two half-cores are assembled.

This method of strickling the core is advantageous for simple and symmetrical forms. In the case of more complicated shapes the mould is lined with loam cakes having the thickness of the casting, whereby a core-box such as is shown in Fig. 8 is obtained.

Castings Moulded partly by Means of Skeleton Patterns and partly by Strickling (Filter shell, weight 5,000 kg.)

Patternmaking.—The preparation of a pattern and a core-box for a casting of this size would be very expensive. By applying the skeleton pattern and strickle method the patternmaking costs are reduced to a minimum.

The patternmaking equipment comprises:—(*a*) A skeleton pattern A for moulding the rectangular attachment; (*b*) a strickling board B for moulding the body of the casting; (*c*) a board C for striking up the internal flange; (*d*) a templet and a scraper for forming the bottom portion D, and (*e*) the lateral print in the core of the attachment.

Moulding.—After having rammed the bottom box, the moulder sets his board and places the skeleton pattern in position, with the aid of the drawing. The skeleton pattern is then filled with sand until it assumes, externally, the aspect of a pattern. The lateral coreprint is then placed in position and the ramming continued up to the joint. It is now necessary to strickle the false mould serving to build up the core. For this purpose the sand which is inside the skeleton is removed and a joint is made to correspond with the external face of the core, while strickling with the board B after removing its end piece. The print for the bottom is also strickled with the aid of the templet and the scraper.

After having completed the joint, the core is made in the usual way. The sectional drawing of the grids and vents. On completing the ramming of the core the joint is made and the top box rammed up. The top is then removed, as also the parts forming the upper portion of the skeleton pattern. The internal flange is struck up with the aid of the board C.

The core is removed, as are also the parts forming the skeleton pattern, while the thickness of the body of the casting is strickled with the board B, fitted with its end piece. A section of the assembled mould is shown in Fig. 9.

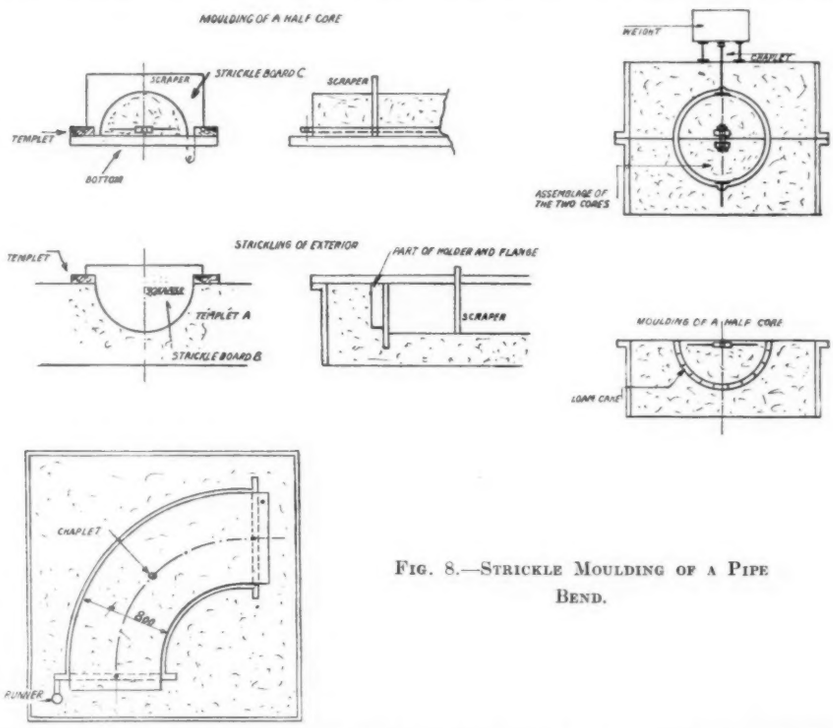


FIG. 8.—STRICKLE MOULDING OF A PIPE BEND.

Strickling with Threaded Spindle (Moulding a Winch Drum, weight 3,000 kg.)

The chief advantage of this special strickling method consists in the great saving effected in respect of machining. The grooves appear in the form of a spiral wound round the generatrices of the cylinder—a combination which enables them to be moulded with a plain metal scraper. The grooves to be reproduced being in spiral form, it is essential that the generatrix spiral should be made on the spindle. For this purpose a special strickle is formed round which the spiral is reproduced, on the lathe, with the pitch desired. A special collar is also required carrying a finger which engages in the spiral thus formed on the spindle.

Patternmaking.—The equipment includes:—(*a*) A strickling board for the cope (this board also serves to form the tangential generatrix at the bottom of the grooves); (*b*) a board for strickling the bottom part; (*c*) a board for strickling the top part; (*d*) a board for strickling the core; (*e*) a metal scraper for strickling the grooves; (*f*) the loose pieces, hubs and ribs.

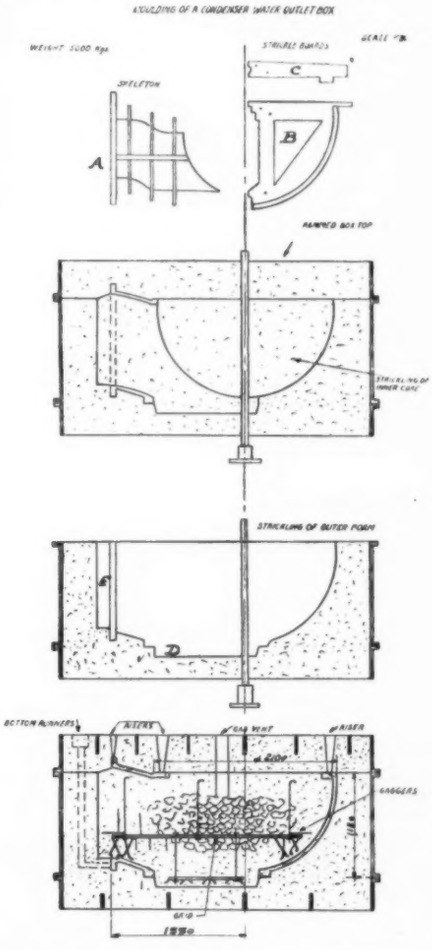


FIG. 9.—EXAMPLE OF COMBINED PATTERN AND STRICKLE MOULDING.

Moulding.—The loose pieces for the mould are made separately. The bottom part includes the moulding of the flange, ribs and hub, the work being carried out with the strickle and various boards.

The body is built up on a plate resting on the bottom joint, and is strickled as shown in Fig. 10. After strickling it is carefully stove-dried, and, after drying, slip loam is prepared for the moulding of the grooves, in such a manner as to prevent abrasion, during strickling, with the metal scraper.

The notch in the upper joint of the body should be noted. This notch permits the centring of the top box, when assembling the mould, by means of a band of loam having a corresponding diameter and section strickled on this box. The

moulding of the top box is effected in the same way as in the bottom box. The core is strickled on a false mould, as shown in Fig. 10.

Strickle Moulding of a Propeller (Four-bladed Propeller, weight 5,250 kg.)

Propellers have two, three or four blades. The blades are strickled and finished consecutively round the hub. Each of them is covered by a special moulding box, a certain number of which are kept by foundries regularly supplying propellers. The hub is covered by a box supported on the boxes for the blades. The principle of the moulding is as follows:—The axes of the blades having been traced (four in the example taken) and with the aid of the guides, to be described later, and after the ramming of the necessary quantity of sand, four curved surfaces are strickled in accordance with the drawing or the guide cone of the propeller. On these four surfaces the outline of the blade and the radii of the different sections are traced consecutively. These sections are cut to templet size in their proper position, the joints between them being made by hand.

Patternmaking.—The strickling tackle, socket and spindle are of the usual type in this case. It is advisable, however, to provide a balanced spindle with handle so as to enable the moulder easily to make contact between the end of his board and the external guide as is shown in Fig. 12. The moulder prepares:—(*a*) A board for strickling the false hub; (*b*) a board A inclined at the angle of the generatrix of the blade; (*c*) four rigid sheet-metal guides 3 to 4 mm. thick, the hypotenuse (*x*) of which represents the continuation of the spiral in accordance with its pitch. These guides are curved, their radius being larger than that of the end of the blade so as to form an external guide; (*d*) a templet of flexible thin sheet metal ½ mm. thick, having the shape of the blade, upon which he traces very distinctly the middle line or axis of the blade, and also the various radii corresponding to the sections—the whole being done in accordance with the working drawing, and (*e*) the desired number of templets in a size corresponding to the various sections and of sheet metal 2 mm. thick, for example, curved in accordance with their respective radii.

Moulding.—After having placed the strickle board in position, the moulder strikes up the false hub in sand, loam, plaster or any other suitable material. Using a straight board, he strikes up an area 120 to 150 cm. wide encircling the radius to which the sheet-metal guides have been bent. This area permits the proper placing of these guides, *i.e.*, at their correct radius and division (four in this case) and exactly vertical to the given area. They are then secured in this position, by ramming with very strong sand inside and outside.

The moulder fills in the sand and rams it firmly between the guides and the hub. Having set up the board A, the moulder strikes up the generatrix surface of the propeller, while pressing the end of his board continuously over the plate guide. He now rams the four boxes with due care. These are to form the top parts of the mould. The moulder marks these boxes and finishes the upper portions. He then traces very carefully the axes of the blades, after which he proceeds to work consecutively on each of the blades and, finally, finishes them.

Placing on the sand the flexible templet C he traces with a stake the external outline, taking care to drive in a stake at each of the points where the various radii of the sections intersect the external outline of the blade. Having removed the templet he takes the quarter section, drives it in, with the rectilinear portion upwards, so that the ends of this section correspond with the first two stakes which he has just placed. He repeats this procedure with the $\frac{3}{8}$, $\frac{1}{2}$, $\frac{5}{8}$, $\frac{3}{4}$, $\frac{7}{8}$ and $\frac{15}{16}$ sections. Thus, marked in the sand, the strickling board is guided by the stakes. Then, with the aid of the templet, he strikes up the sand between the stakes, and finishes the surface with a trowel. He then proceeds carefully to join, with the trowel, all these parts one to the other, so as to incurvated shapes of the sections are obtained. On removing the sections, the moulder sprinkles a small quantity of talc over this bottom mould so that it may show up clearly.

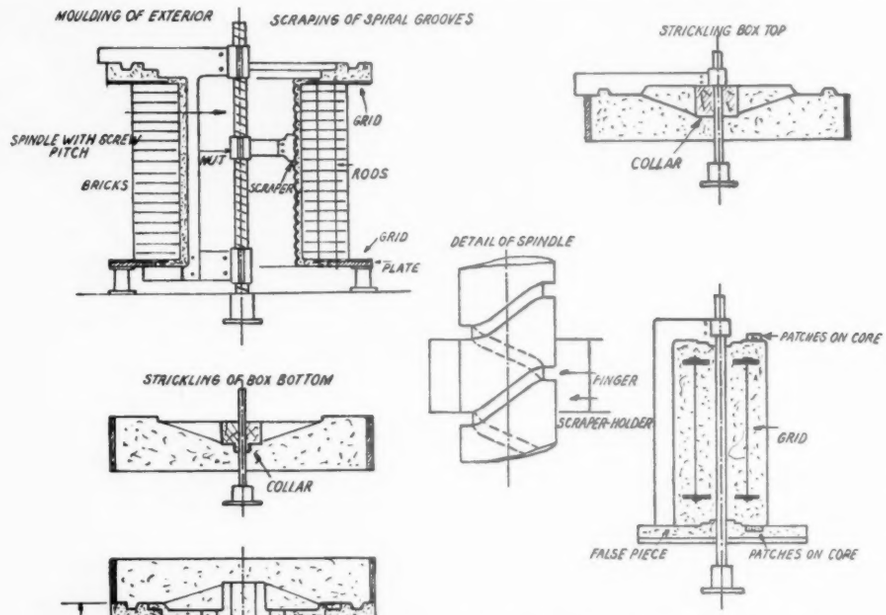


FIG. 10.—MOULDING OF A WINCH DRUM.

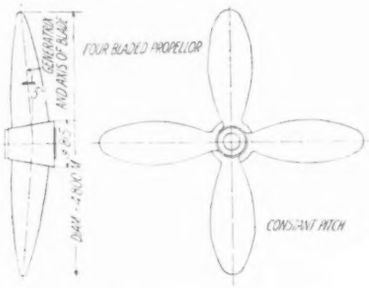


FIG. 11.—EXAMPLE OF CURVILINEAR MOULDING.

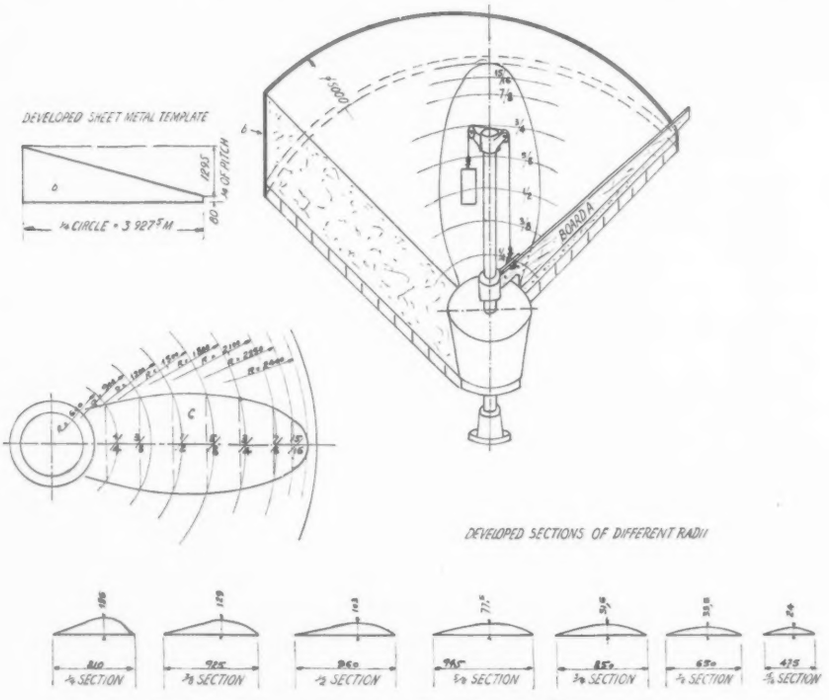
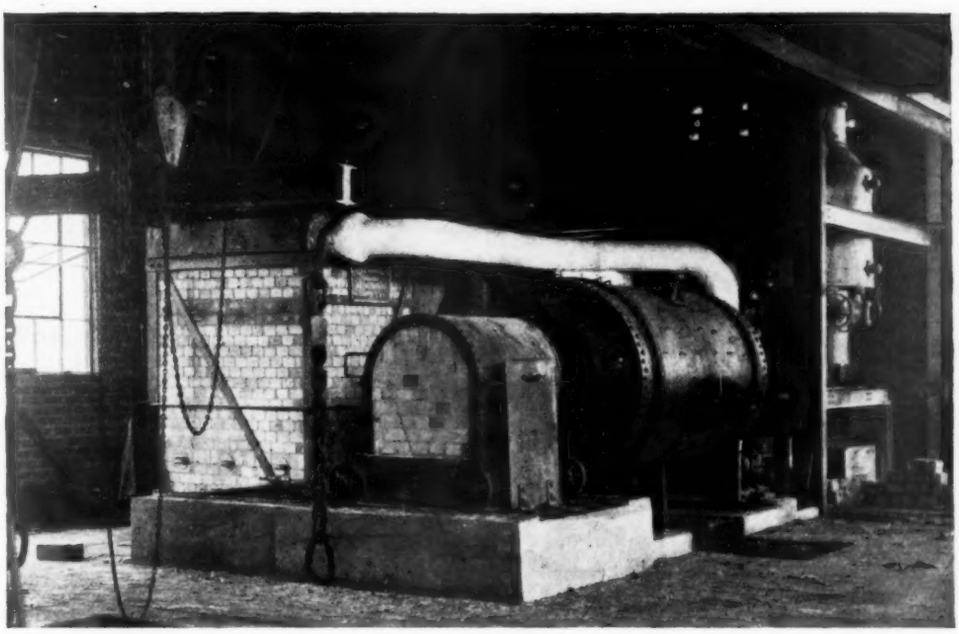


FIG. 12.—MOULDING OF A FOUR-BLADED PROPELLER.



A 1½-ton capacity Oil-fired Rotary Furnace
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obtain the general form of the lower portion of each blade. When the blades are finished, he removes the false hub and assembles his mould.

Conclusion

As was intimated at the outset, the authors have not attempted to give a precise definition of the general practice of strickle moulding. Their British confrères are only too familiar with it already. On the other hand, they have instanced several cases where the application of strickle moulding present characteristic features. Readers will perhaps be surprised at their having selected in every instance very simple castings by way of example. They thought that by so doing the various working methods as applied to the example selected could be more easily followed than by means of complicated drawings.

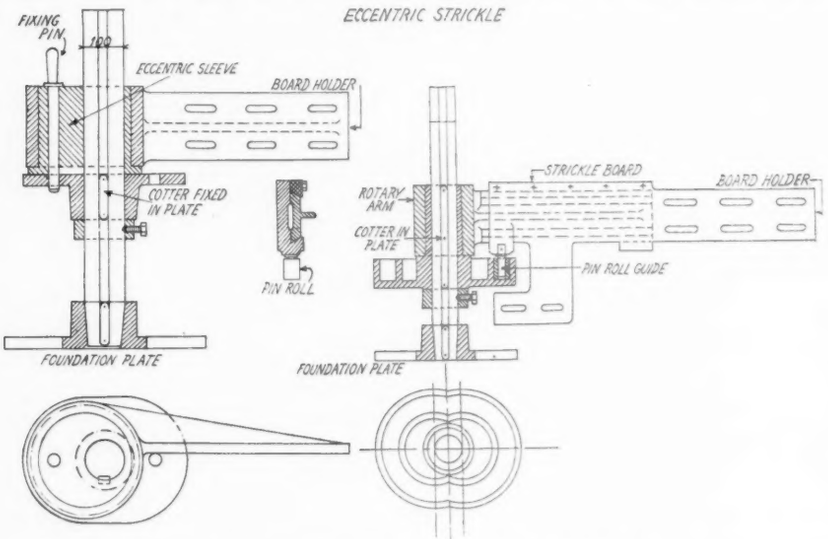

FIG. 13.—ARRANGEMENT FOR ECCENTRIC STRICKLING.

Moreover, it would have been impossible to have given, within the very narrow limits of an exchange Paper, all the details which complicated examples would have necessarily entailed.

Such as it is, this simple Paper may perhaps, in respect to several points, arouse the attention of some of their confrères whose method of working differs from those of the authors. Any criticism which may be made of any particular method will be welcomed as being conducive to progress, and in this the authors will find their best reward.

Corrosion Research in the United States

One of the most effective means for reducing the loss occasioned by soil corrosion of pipe lines is by the proper selection and application of protective coatings at the time the line is constructed. The general use of effective coatings will, of course, reduce corrosion, but in general the maximum saving will not be effected because protection is not necessary in all soils. Methods for repairing or reconditioning the corroded parts of the line have been greatly improved and some engineers believe the most economical way to combat corrosion is to lay the line bare and later to recondition and coat the badly-corroded parts of the line. The American Gas Association and the U.S. Bureau of Standards have co-operated in the development of a method which is a combination of three widely-different methods that have been suggested by others, and the survey is carried out in such a way that the cost is very small. The methods consist in mapping the soil types and in determining the average acidity and average electrical resistivity of each type. A further advantage of the method is that the corrosiveness of the soil is expressed in terms of costs, so that coatings can be selected and applied in such a way that the total average annual cost of combating corrosion is reduced to the lowest possible amount. The methods have been tested on one old and rather extensive pipe-line system and have been shown to be economical in this case.

Iron and Steel Institute

AUTUMN MEETING AT MANCHESTER

The Autumn Meeting of the Iron and Steel Institute for 1935, as previously announced, will be held at Manchester. A reception committee representing the iron, steel and engineering industries of Manchester and Lancashire, has been formed, and of this the Rt. Hon. the Earl of Crawford and Balcarres, P.C., K.T., is the President, Mr. J. E. James the chairman, Alderman F. J. West the hon. treasurer, and Mr. H. D. Lloyd the hon. secretary. The committee includes representatives of works on the Cumberland coast to which invitations to pay visits have been received. The provisional programme is summarised below.

Monday, September 16.

The secretary's office will be open at the Manchester College of Technology, from 3 to 7 p.m., for the registration of members and for the distribution of programmes, badges and tickets.

Tuesday, September 17.

9.30 a.m.—General meeting in the Hall of the Manchester College of Technology. Welcome by the Lord Mayor of Manchester, and the President, chairman and members of the Reception Committee. Ladies are invited to be present at the official welcome. Reading and discussion of Papers.

Excursion No. 1.—During the morning visits will be made by the ladies to the showrooms of the Tootal Broadhurst Lee Company, Limited, and/or the showrooms of Rylands & Sons, Limited. Alternative visits will also be arranged to Rylands' Library, New Free Library, and Chetham's Library.

12.30 p.m.—Members and their ladies will be entertained to luncheon at the Midland Hotel, Manchester, by the Reception Committee.

2 p.m.—Visits will be paid by the members to the works of the following companies:—Metropolitan Vickers Electrical Company, Trafford Park; Mather & Platt, Limited, Park Works; Taylor Bros. & Company, Limited, Trafford Park; Renold & Coventry Chain Company, Limited, Renold Works, Didsbury; Rylands Bros., Limited, Warrington. During the afternoon the ladies will inspect the new housing scheme of the Manchester Corporation and take tea at Wythenshawe Park.

8 p.m. for 8.30 p.m.—A civic reception to the members and ladies will be given by the Lord Mayor and Corporation of the City of Manchester at the Town Hall.

Wednesday, September 18.

9 a.m.—General meeting in the Students' Common Room of the Manchester College of Technology. Reading and discussion of Papers.

11.45 a.m.—The members will embark at Salford Docks, on vessels provided by the Manchester Ship Canal Company, for a visit to the Irlam works of the Lancashire Steel Corporation, Limited.

1.15 p.m.—Lunch will be taken at Irlam by invitation of the Lancashire Steel Corporation, Limited, and will be followed by visits to the coke ovens, blast furnaces, steel plant and rolling mills.

9.30 a.m.—An excursion to the Peak District of Derbyshire has been arranged for the ladies, who will leave by motor coach to Chatsworth, where a visit will be paid to Chatsworth House and grounds, by permission of His Grace the Duke of Devonshire, K.G. (Past-President). Lunch will be taken at Buxton. On the return journey the ladies will be entertained to tea by invitation of Mr. and Mrs. J. E. James at Ollerton Grange, Knutsford.

7.30 p.m.—Members and their ladies will be entertained at a banquet, followed by a dance, at the Midland Hotel, Manchester, by invitation of the Reception Committee.

In addition to the official visits to works mentioned above, the following companies have expressed their willingness to receive members of the Institute during the afternoons of September 17 and 18:—The Churchill Machine Tool Company, Limited, Broadheath, Altrincham; Craven Bros. (M/C), Limited, Vauxhall Works, Reddish, Stockport; Ferranti, Limited, Hollinwood, Manchester; National Gas & Oil Engine Company, Limited, Ashton-under-Lyne; Geo. Richards & Company, Limited, Broadheath, Altrincham; Henry Simon, Limited, Bird Hall Lane, Cheadle Heath, Stockport; West's Gas Improvement Company, Limited, Albion Ironworks, Miles Platting, Manchester.

Thursday, September 19.

Excursion to works on the Cumberland coast and visit to the Lake District. By kind permission of the United Steel Companies, Limited, and the Millom & Askam Hematite Iron Company, Limited, the members will visit the works at Moss Bay and at Millom. Details of the itinerary will be announced later. Provisionally, it has been arranged that the party shall leave Manchester by special train at approximately 8.30 a.m., and it is anticipated that they will transfer to motor coaches for the journey through the Lake District. Lunch will be taken at the Keswick Hotel, Keswick, by invitation of the United Steel Companies, Limited, and the Millom & Askam Hematite Iron Company, Limited.

After lunch the party will divide; it is proposed that those visiting works shall travel by motor coach from Keswick past Bassenthwaite Lake to the Moss Bay Works, Workington, of the United Steel Companies, Limited, and then by the coast road to the works at Millom of the Millom & Askam Hematite Iron Company, Limited. They will then proceed to Ulverston.

An alternative visit to the Lake District has been arranged.

Palmers Hebburn Company

Extensions and improvements are to take place at the ship-repairing works of Messrs Palmers Hebburn Company, Limited, Hebburn-on-Tyne, following the purchase of the share capital of the company by Messrs. Vickers-Armstrongs, Limited. The new board of directors is as follows:—Sir Charles W. Craven (chairman), Col. D. R. MacDonald, Mr. A. J. Hendin, Commander E. R. Micklem, Mr. W. Leslie Runciman and Mr. E. L. Champness. New machinery is being installed.

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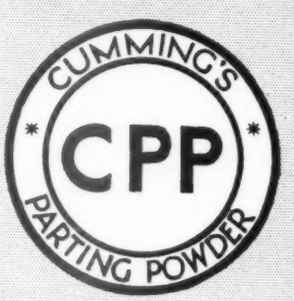

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This Week's News in Brief

Trade Talk

THE COMMITTEE of the London Metal Exchange has decided that Saturday trading shall be suspended during the months of July and August.

IT WAS ANNOUNCED recently that Messrs. Thomas W. Ward, Limited, of Sheffield, had been instructed to proceed with the demolition of redundant units of Palmers' blastfurnaces and steelworks at Jarrow.

THE CLYDE ENGINEERING COMPANY, LIMITED, has received large orders for railway equipment for the New South Wales Government Railway Department. The contract includes the construction of ten first-class and five second-class coaches at a cost of £3,530 each, 50 manual Sheffield trolleys and 99 trailers.

WORK HAS COMMENCED on the replacement of "C" furnace at the Steel Company of Scotland's Hallside Works, Newton, and will continue throughout the Glasgow Fair holidays. The new furnace, when completed, will have a capacity for between 50 to 60 tons, instead of approximately 35 tons. The works reopen on July 22.

THE NUMBER of electric furnaces installed in Japan totalled 38 at the end of 1928, with a total capacity of 25,100 kw., but increased to 89 with a total capacity of 55,930 kw. at the end of 1933. The furnaces have also been enlarged considerably in capacity, the largest now having a maximum capacity of 4,500 kw., although those with a capacity of 600 kw. are still the largest in number.

AN EXHIBITION designed to illustrate all phases of electrodeposition and the scientific principles upon which it is based will be held at the Science Museum, South Kensington, London, from July to October, 1935, by permission of the Director, Col. E. E. B. Mackintosh, D.S.O. An interesting feature of the Exhibition will be a cinematograph film showing some of the commercial applications of electrodeposition. The Exhibition will be open free to the public daily from 10 a.m. to 6 p.m. (Sunday 2.30 to 6 p.m.). The Exhibition is being organised by the Electrodepositors' Technical Society, Northampton Polytechnic Institute, London, E.C.1, to whom all inquiries should be addressed.

IT IS ANNOUNCED in Dublin that the Free State Government has granted a licence to a Birmingham concern, whose name has not yet been disclosed, for the establishment of a hollow-ware factory at Waterford, and work on the new building will commence immediately. The original project to manufacture grates and ranges only has been much amplified, and numerous other articles of hardware will now come within the ambit of the new factory. Imports of hollow-ware into the country for the month of May totalled £10,176, making for the first five months of the year £48,468. When operations commence at Waterford the Government, it is stated, will be asked to place a prohibitive tariff on hollow-ware imports.

SIR JOHN JARVIS, formerly High Sheriff of Surrey, who started the Surrey County adoption scheme for Jarrow, has bought a steamer for breaking up in Jarrow. Referring to a rumour that work at Jarrow steelworks was likely to be started immediately, Sir John Jarvis said recently that such statements must be taken with considerable reserve since, so far as his information went, he could learn no justification for those anticipations. On the other hand, he heard of no hitch in the negotiations, but those were necessarily complicated, and there were reconciliations of interests which could not be settled as quickly as he would like.

Company Report

W. & T. Avery, Limited.—Net profit, £124,087; brought in, £59,589; dividends for the year on 5 per cent. "A" preference shares, £5,243; 5½ per cent. "B" preference dividends, £6,321; final dividend on the ordinary shares of 10 per cent., making 15 per cent. for the year; to reserve, £30,000; carried forward, £60,483. The directors propose to capitalise the sum of £142,363 by distributing to ordinary shareholders a free bonus of one new share for every five shares held. The cost will be met from the reserve fund, which is also to provide £100,000 for a new staff pension scheme. Meeting July 23.

Personal

MR. DONALD SKIFFINGTON, shipyard director of Messrs. John Brown & Company, Limited, Clydebank, has left for a tour of the United States.

MR. J. BUCKLER MCTURK, managing director of the Dorrator Iron Company, Limited, Falkirk, who is partially retiring, has received presentations from the company and the staff. Mr. McTurk has been with the company for 25 years, and has been managing director for 20 years. He will retain his position on the directorate and will be responsible for the company's interests in the Irish Free State.

MR. W. WOOD, who is celebrating his silver jubilee as works manager of Messrs. John Ruscoe & Company, Limited, of the Albion Works, Hyde, and the Hope Foundry, Newton, was the recipient of presentations from the employees on the occasion of their recent annual outing. On behalf of Hope Foundry workers, Mr. W. Whiteley, the cashier, gave Mr. Wood a silver cigarette case suitably inscribed. Mr. Fred Bowker, on behalf of the employees of Messrs. John Ruscoe & Company, Limited, asked Mr. Wood to accept a gold luminous wristlet watch. Mr. Wood suitably acknowledged the gifts.

THE COUNCIL of the Royal Society of Arts attended at Clarence House recently, when the Duke of Connaught, President of the Society, presented the Society's Albert Medal for 1935 to Sir Robert Hadfield, Bt., F.R.S., "for his researches in metallurgy and his services to the steel industry." In making the presentation the Duke of Connaught said that Sir Robert Hadfield's labours in the application of scientific research to the steel industry had contributed greatly to its progress. As far back as 1882, by the discovery of manganese steel, he opened a new chapter in the history of metallurgy, and by a long series of experimental investigations, continued down to the present day, he had added greatly to the knowledge of alloy steels.

Wills

THOMPSON, J. D., of Stockton-on-Tees, iron merchant	£27,784
NEILSON, JOHN, of Cleveden Drive, Glasgow, ironmaster	£154,765
ANDERSON, JOHN THOMSON, 48, Rennie Street, Falkirk, retired ironfounder...	£6,115

Contracts Open

Sheppey, July 24.—105 tons of cast-iron pipes and special castings, 3 in. dia., for the Rural District Council. Mr. H. T. Copland, clerk, Clerk's Office, Sheerness.

Johannesburg, August 19.—One 36-ton steam travelling breakdown crane, for the South African Railways and Harbours Administration. The Department of Overseas Trade. (Reference T.Y. 5,018.)

Johannesburg, August 26.—One 60-ton steam travelling breakdown crane, for the South African Railways and Harbours Administration. The Department of Overseas Trade. (Reference T.Y. 5,019.)

Burton Joyce, July 22.—Providing and laying 92 yds. of 6-in. cast-iron pipe sewer, with manholes, etc., in the parish of Burton Joyce, for the Basford Rural District Council. Mr. J. J. Ellis, engineer, Rock House, Stockhill Lane, Basford, Nottingham. (Fee £1 15s., returnable.)

New Companies

(From the Register compiled by Jordan & Sons, Limited, Company Registration Agents, 116 to 118, Chancery Lane, London, W.C.2.)

H. Jaeger, Limited.—Capital £250 in £1 shares. Iron and iron-ore merchants, etc. Subscriber: H. Jaeger, 4, Shirehall Park, London, N.W.14.

Scotia Iron & Chemical Company, Limited, 36, New Broad Street, London, E.C.—Capital £1,000. To enter into an agreement with the Scottish Iron Corporation, Limited, and to carry on the business of iron masters, steel makers, etc.

Obituary

MR. THOMAS WILKINSON, Managing Director of the firm of Messrs. Thomas Wilkinson & Company, Limited, of Middlesbrough and Stillington, manufacturers of blacking and other foundry requisites, and a director of the Eaglescliffe Brick Company, Limited, died suddenly last Saturday.

SIR HUGH REID, BT., chairman and chief managing director of the North British Locomotive Company, Limited, has died at Belmont, Springburn, Glasgow. The eldest son of the late James Reid, of Auchterarder, Perthshire, Sir Hugh was born in Manchester in 1860. He was created a baronet in 1922.

Harco Products, 1874-1934

Messrs. G. A. Harvey & Company (London), Limited, Woolwich Road, London, S.E.7, have issued a handsome Diamond Jubilee Catalogue No. 650, "Harco Products, 1874-1934," which covers comprehensively the whole range of products manufactured by them. The book comprises 640 pages and has many hundreds of illustrations. The various products have been classified according to description of materials and method of manufacture, the main sub-divisions covering sheet-metal work of all kinds, zinc and copper work, perforated metals for a wide variety of uses, woven wire for screening and filtering, etc., wirework, steel equipment for offices and works, cast goods, and steel-plate work, which latter includes industrial plant of every description. The catalogue gives full specifications for all products with dimensions and prices.

Quality of Electric Steel

(Concluded from page 42.)

cent., Cr 4 per cent., V 2.5 per cent. The following factors were studied: (1) Carbide distribution. (2) Hardness. (3) Soundness. (4) Cutting power. As mentioned above, these melts were made in 1 and 4-ton high-frequency furnaces with acid linings. They were compared with steels of the same analysis carefully made in the basic electric-arc furnace.

(1) The carbide distribution was determined by a microscopic comparison, and graded by comparison with four standard samples, sample 1 having the best distribution and sample 4 the worst. In the summation there was practically no difference in the two varieties of steels.

(2) Hardness of all the high-frequency melts was better than the arc-furnace steel after air hardening from 2,350 deg. Fah.

(3) A number of tapered bars were twisted in order to determine the possible presence of fine cracks in different cross-sections of the steel. An evaluation of the number, length, and width of the cracks was made by comparison with four standard pieces and no essential difference was found. This test was made on the steel with 2.5 per cent vanadium.

(4) Lathe tools were heated in a gas-muffle furnace to about 2,375 deg. Fah. quenched in oil, tempered for 20 min. at 1,025 deg. Fah. in a lead bath with subsequent air cooling. Hardness of the steel was measured by the Rockwell test. Cutting tests were made with a speed of 60 ft. per min., depth of cut 0.118 in., and feed of 0.040 in. The test log was an open-hearth steel shaft having about 53 tons per sq. in. tensile strength. Shafts were machined from 14 to about 8 in. dia. No difference could be found between the tools made of high-frequency steel and those made of electric-arc furnace steel.

It may fairly be said, concludes the writer, that neither the type of melting nor the lining makes any difference, if first-class melting practice be followed. The slight differences likely to be due to these causes may perhaps be submerged by the action of the alloying elements.

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Raw Material Markets

An unusually good demand, for this period of the year, prevails in the iron and steel markets, and it is expected that in many instances annual holidays will be shortened, in order to allow the producers to keep up their output. Pig-iron is being consumed on a large scale. The price of hematite was increased by 2s. 6d. per ton for delivery in specified areas at a meeting of the producers last week. Meetings between representatives of the British Iron and Steel Federation and the Continental Steel Cartel are being continued and the ultimate outcome is awaited with interest.

Pig-Iron

MIDDLESBROUGH.—Production of hematite and foundry iron for the open market is confined to only nine blast furnaces in this area, and steps to expand the output have already been taken by producers. Good inquiries from home consumers of pig-iron have been received, and, in spite of the Scottish holidays, conditions remain favourable. The supply is barely enough for home demands. The fixed home prices of Cleveland iron are all unchanged.

The increased demand for hematite since the beginning of the second half of the year is maintained and deliveries under contract are on a big scale. Currency transfers remain the stumbling block to Italian exports, but a few small quantities have been shipped to other foreign countries. Two more blast furnaces are expected to be relighted about July 25 and these should increase the output considerably. The future may be regarded very confidently, and at a meeting of the manufacturers last week prices were increased by 2s. 6d. per ton for most destinations. The prices of No. 1 East Coast hematite delivered in the various districts are as follow:—Middlesbrough, 69s. per ton. North-East Coast 71s., Scotland 77s. 6d., Lancashire 78s. 6d., Birmingham 81s. 6d. and South Wales 71s. per ton.

LANCASHIRE.—Very few large orders for pig-iron have been placed in this district and business is chiefly confined to small quantities for early delivery. The Cotton Industries Spinning Bill will react on the pig-iron trade, for large quantities of machinery are expected to be thrown on the scrap market. The heavy-engineering and machine-tool making industries continue to take large quantities of foundry iron and other products. The light-castings trade is also favourable. Derbyshire, Staffordshire and Lancashire brands of No. 3 iron for delivery to users in the Lancashire zone are all quoted on the basis of 74s. per ton, with Northants at 72s. 6d., Derbyshire forge iron at 69s., Scottish foundry at about 82s., West Coast hematite at 81s., and East Coast material at from 77s. 6d. to 78s. 6d.

MIDLANDS.—The market is rather quiet, due to many of the ironfounders still having supplies to be delivered against old contracts. Light castings manufacturers are fairly well engaged, but not to the extent that had been expected. General jobbing and engineering foundries are busier, and a large tonnage of pig-iron is being sent out from Black Country furnaces. The controlled minimum prices for No. 3 Midland iron are 67s. 6d. per ton for Northants and 71s. for Derbyshire, Lincolnshire and North Staffordshire, including delivery to Birmingham and Black Country stations, and subject to a small graduated rebate to large consumers. Forge pig-iron remains at 5s. below the foregoing prices. Refined iron for special work is between £5 7s. 6d. and £6. Medium-phosphorus iron is between 72s. and 80s., and low-phosphorus, including Scottish, from 85s. to 90s. per ton delivered this district. West-Coast hematite is at 87s. and East Coast No. 3 is at 80s. 6d. Welsh hematite is also obtainable at 80s. 6d. per ton. Hematite prices are 2s. 6d. higher on the week.

SCOTLAND.—Work in the Falkirk area has been resumed, but a complete stoppage of the iron and steel foundries in the Glasgow district, for 10 days or so, began last Friday. Consequently, the market is practically at a standstill. Clyde shipments abroad for last week amounted to 578 tons; the corresponding total for last year was only 55 tons. Although deliveries of English common iron to the light-castings founders have been resumed, no change in prices has been reported.

Coke

This market remains very dull, as was predicted. No official reduction in the price of best Durham fuel has been reported, quotations for delivery in the Birmingham and Black Country area ranging from 34s. to 40s. Welsh varies according to quality, from 31s. up to 42s. 6d., and Scottish low-ash coke is quoted at prices between 39s. 6d. and 40s. 6d. per ton, also delivered Birmingham.

Steel

There has been some slackening in business in the steel market, but this is to be expected, as the holiday season in most of the industrial districts is now influencing trading conditions. Nevertheless, the volume of business in most departments is well in excess of that for the corresponding period of last year. There has been a lull in the demand for semi-finished steel, but this is not surprising in view of the heavy buying which has taken place recently. Many consumers have contracted for deliveries until the autumn and others are carrying considerable stocks. It is anticipated also that the Continental sellers will shortly reopen their books for delivery in the latter part of August, and this probably has had a tendency to slow down trading. In the finished-steel section business has been active on home account, although the export demand remains disappointing. Substantial deliveries of most classes of steel products continue to be made. Practically all the works have good order-books and most of them can see their way to maintaining the present rate of operations for some months.

Scrap

Demand remains fairly active in the Cleveland district and prices are firm. Cast-iron scrap is readily taken up and good machinery metal broken in handy sizes is realising 53s. The Midland market has become less active, but prices remain fairly firm. Heavy steel in furnace sizes is at 44s. to 45s. and mixed heavy iron and steel at 42s. 6d. to 43s. 6d. Heavy wrought-iron scrap is at 57s. 6d. and heavy machinery metal in cupola sizes is at 55s. to 57s. 6d. Very little change has occured in the Yorkshire market and heavy basic steel for melting is being taken up well at 51s. 6d. The other scrap metals are quiet and show little alteration. On the Lancashire market buying has dropped a little owing to area holidays, but the consumption has been fairly well maintained. Cast-iron scrap of good machinery quality ranges from about 47s. 6d. to 55s. per ton, according to grade and the position of supplies, these prices including delivery to Lancashire works. The annual holidays, which commenced at the end of last week, have caused a dull tone to prevail on the Scottish market. Prices remain firm and are as follow:—Heavy iron and steel scrap mixed, 45s., good piling wrought-iron 57s. 6d., clean cast-iron borings 37s. 6d. to 39s., and first-class machinery cast-iron scrap, in pieces not exceeding 1 cwt., 57s. 6d. per ton, delivered f.o.t. consumers' works.

Metals

Copper.—A firmer tone prevails. Buying has been good in America, but rather quiet in European markets. A meeting of copper producers is being held in London this week, but very few developments are expected as a result. Consumption of this metal has been satisfactorily maintained on the whole, and if there are no disturbing rumours from America a further recovery may be expected.

Daily market prices:—

Cash.—Thursday, £31 1s. 3d. to £31 2s. 6d.; Friday, £31 2s. 6d. to £31 5s.; Monday, £32 1s. 3d. to £32 2s. 6d.; Tuesday, £32 2s. 6d. to £32 5s.; Wednesday, £31 13s. 9d. to £31 15s.

Three Months.—Thursday, £31 8s. 9d. to £31 11s. 3d.; Friday, £31 11s. 3d. to £31 12s. 6d.; Monday, £32 10s. to £32 11s. 3d.; Tuesday, £32 11s. 3d. to £32 12s. 6d.; Wednesday, £32 2s. 6d. to £32 3s. 9d.

Tin.—The market for tin is still firm, but very few fresh developments are reported and the general tone is dull. American demand has dropped a little, but is still quite good. A moderate inquiry is reported from the Continent and the same applies to home requirements. Prices have been fairly well maintained.

Day-to-day fluctuations:—

Cash.—Thursday, £231 2s. 6d. to £231 5s.; Friday, £231 5s. to £231 15s.; Monday, £232 to £232 5s.; Tuesday, £232 10s. to £232 15s.; Wednesday, £232 15s. to £233.

Three Months.—Thursday, £224 5s. to £224 10s.; Friday, £224 10s. to £224 15s.; Monday, £224 10s. to £224 12s. 6d.; Tuesday, £224 5s. to £224 10s.; Wednesday, £224 10s. to £224 15s.

Spelter.—This metal has kept steady this week, but prices are below those of lead, which is very unusual. A firm undertone is reported from the Continent, but in spite of consumption being maintained, the price has not recovered so much as was expected. The American market continues to be very poorly supported and prices are still unchanged.

Official quotations were as follow:—

Ordinary.—Thursday, £13 18s. 9d.; Friday, £13 16s. 3d.; Monday, £13 17s. 6d.; Tuesday, £13 17s. 6d.; Wednesday, £13 16s. 3d.

Lead.—Firm conditions prevail and prices have risen in a confident manner. Consumption is at a high level in the home market. Continental demand is also good and no surplus metal weighs on the market. The American market is firm and the price has advanced in a corresponding manner. On the whole, the lead market is very satisfactory, both at home and abroad.

Day-to-day quotations:—

Soft Foreign (Prompt).—Thursday, £14; Friday, £14 1s. 3d.; Monday, £14 2s. 6d.; Tuesday, £14 2s. 6d.; Wednesday, £14 7s. 6d.

Factories and Workshops Report

The Annual Report of the Chief Inspector of Factories and Workshops for the year 1934 has been issued by the Home Office and may be obtained from H.M. Stationery Office, Adastral House, Kingsway, London, W.C.2 (price 2s. net). It contains the usual chapters relating to the general report, safety, health, hours of employment, welfare, piecework particulars, truck, and the Home Office Industrial Museum, as well as a series of tables relating to registered works, accidents, etc.; works under regulations, contravention notices issued to occupiers, notices to district councils, medical examinations, prosecutions, prosecutions relating to regulations, accidents, according to industry, age and sex, etc., distribution of factories according to size, and the administration of the Factory Acts (1924-34).

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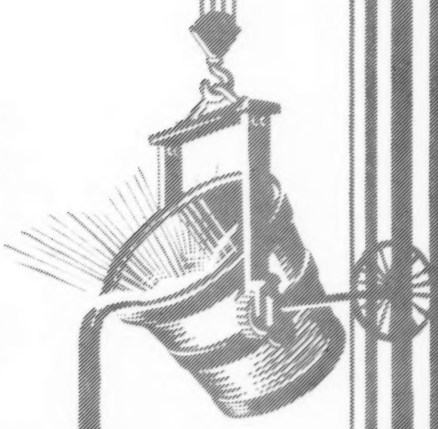

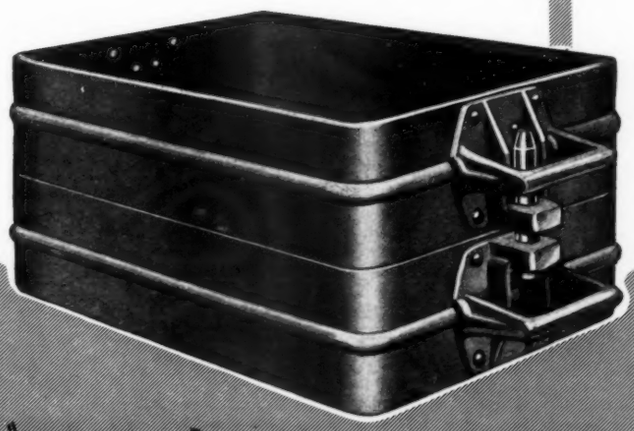

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LONDON OFFICE: 13 VICTORIA STREET, WESTMINSTER, S.W.1.

XUM

RAW MATERIALS—PRICE LIST

(Wednesday, July 17, 1935)

COPPER

	£ s. d.
Standard cash	31 13 9
Three months	32 2 6
Electrolytic	35 5 0
Tough	33 15 0
Best selected	34 10 0
Sheets	62 0 0
India	45 10 0
Wire bars	36 0 0
Ingot bars	36 0 0
H.C. wire rods	39 10 0
Off. av. cash, June	30 16 8 11/16
Do., 3 mths., June	31 4 1 1/16
Do., Sttlmnt., June	30 16 10 5/16
Do., Electro, June	34 7 4 1/16
Do., B.S., June	33 13 1 1/2
Do., wire bars, June	34 13 11 7/16
Solid drawn tubes	9d.
Brazed tubes	11d.
Wire	7 3/8d.

BRASS

Solid drawn tubes	9d.
Brazed tubes	11d.
Rods, drawn	8d.
Rods, extd. or rlld.	4 1/2d.
Sheets to 10 w.g.	7 3/8d.
Wire	7 3/8d.
Rolled metal	6 3/4d.
Yellow metal rods	4 1/2d.
Do. 4 × 4 Squares	5 1/2d.
Do. 4 × 3 Sheets	5 3/4d.

TIN

	£ s. d.
Standard cash	232 15 0
Three months	224 10 0
English	232 15 0
Bars	234 10 0
Straits (nom.)	242 15 0
Australian (nom.)	233 5 0
Eastern	230 15 0
Banca (nom.)	238 15 0
Off. av. cash, June	227 14 3 8/16
Do., 3 mths., June	219 10 9 9/16
Do., Sttlmt., June	227 14 5 13/16

SPELTER

	£ s. d.
Ordinary	13 16 3
Remelted	14 10 0
Hard	11 10 0
Electro 99.9	16 7 6
English	14 17 6
India	12 15 0
Zinc dust	18 10 0
Zinc ashes	3 5 0
Off. aver., June	13 16 3 15/16
Aver. spot, June	13 14 8 1/16

LEAD

	£ s. d.
Soft foreign ppt.	14 7 6
Empire (nom.)	15 5 0
English	16 5 0
Off. average, June	13 15 9 3/8
Average spot, June	13 15 6 1/16

ALUMINIUM

Ingots	£100 to £105
Wire	1/1 to 1/9 lb.
Sheet and foil	1/2 to 2/9 lb.

ZINC SHEETS, &c.

	£ s. d.
Zinc sheets, English	22 17 6
Do., V.M. ex-whse.	23 10 0
Rods	28 10 0

ANTIMONY

	£ s. d.
English	74 0 0 to 75 0 0
Chinese, ex-whse.	70 0 0
Crude, c.i.f.	25 10 0

QUICKSILVER

Quicksilver	11 2 6 to 11 12 6

FERRO-ALLOYS AND STEEL-MAKING METALS

Ferro-silicon—	
25%	8 17 6
45/50%	12 15 0
75%	17 17 6
Ferro-vanadium—	
35/50%	12/8 lb. Va.
Ferro-molybdenum—	
70/75% carbon-free	4/6 lb. Mo.
Ferro-titanium—	
23/25% carbon-free	9d. lb.
Ferro-phosphorus, 20/25%	£15 15 0
Ferro-tungsten—	
80/85%	3/- lb.
Tungsten metal powder—	
98/99%	3/3 lb.
Ferro-chrome—	
2/4% car.	33 10 0
4/6% car.	21 15 0
6/8% car.	21 0 0
8/10% car.	21 0 0
Ferro-chrome—	
Max. 2% car.	34 0 0
Max. 1% car.	36 5 0
Max. 0.70% car.	37 5 0
70%, carbon-free	9 3/4d. lb.
Nickel—99.5/100%	£200 to £205
"F" nickel shot	£184 0 0
Ferro-cobalt, 98/99%	5/6 lb.
Metallic chromium—	
96/98%	2/5 lb.
Ferro-manganese (net)—	
76/80% loose	£10 15 0 to £11 5 0
76/80% packed	£11 15 0 to £12 5 0
76/80% export	(nom.) £9 15 0
Metallic manganese—	
94/96% carbon-free	1/8 lb.

Per ton unless otherwise stated.

HIGH-SPEED TOOL STEEL

Finished bars, 14% tungsten	2s. 0d.
Finished bars, 18% tungsten	2s. 9d.

Per lb. net, d/d buyers' works.

Extras—	
Rounds and squares, 3 in. and over	4d. lb.
Rounds and squares, under ½ in. to ¼ in.	3d. lb.
Do., under ¼ in. to 7/16 in.	1/- lb.
Flats, ½ in. × ¼ in. to under 1 in. × ⅜ in.	3d. lb.
Do., under ¼ in. × ¼ in.	1/- lb.
Bevels of approved sizes and sections	6d. lb.

Bars cut to length, 10% extra.

SCRAP

South Wales—	£ s. d.	£ s. d.
Heavy steel	2 15 0	to 2 16 0
Bundled shrngs.	2 7 6	to 2 16 0
Mixed iron and steel	2 10 0	to 2 12 0
Heavy cast iron	2 10 0	to 2 12 0
Good machinery	2 12 6	to 2 15 0

Cleveland—	£ s. d.
Heavy steel	2 12 6
Steel turnings	1 15 0
Cast-iron borings	1 5 0
Heavy cast iron	2 12 6
Heavy machinery	2 14 0 to 2 15 0

Midlands—	£ s. d.
Light cast-iron scrap	2 7 6
Heavy wrought iron	2 17 6
Steel turnings	1 14 0

Scotland—	£ s. d.
Heavy steel	2 10 0
Ordinary cast iron	2 12 6
Engineers' turnings	1 19 6
Cast-iron borings	1 17 6 to 1 19 6
Wrot-iron piling	2 17 6
Heavy machinery	2 17 6

London—Merchants' buying prices, delivered yard.

	£ s. d.
Copper (clean)	26 0 0
Brass	17 0 0
Lead (less usual draft)	12 10 0
Tea lead	9 10 0
Zinc	8 10 0
New aluminium cuttings	66 0 0
Braziery copper	22 0 0
Gunmetal	24 0 0
Hollow pewter	155 0 0
Shaped black pewter	110 0 0

PIG-IRON

N.E. Coast (d/d Tees-side area)—	
Foundry No. 1	70/-
Foundry No. 3	67/6
,, at Falkirk	67/3
,, at Glasgow	70/3
Foundry No. 4	66/6
Forge No. 4	66/6
Hematite No. 1	69/-
Hematite M/Nos.	68/6
N.W. Coast—	
Hem. M/Nos. d/d Glas.	75/-
,, d/d Birm.	87/-
Malleable iron d/d Birm.	115/-
Midlands (d/d Birmingham dist.)—	
Staffs No. 4 forge	67/-
,, No. 3 fdry.	71/-
Northants forge	63/6
,, fdry. No. 3	67/6
,, fdry. No. 1	70/6
Derbyshire forge	67/-
,, fdry. No. 3	71/-
,, fdry. No. 1	74/-
Scotland—	
Foundry No. 1, f.o.t.	72/6
,, No. 3, f.o.t.	70/-
Hem. M/Nos. d/d	71/-
Sheffield (d/d district)—	
Derby forge	64/6
,, fdry. No. 3	68/6
Lincs forge	64/6
,, fdry. No. 3	68/6
W.C. hematite	86/-
Lancashire (d/d eq. Man.)—	
Derby fdry. No. 3	74/-
Staffs fdry. No. 3	74/-
Northants fdry. No. 3	72/6
Cleveland fdry. No. 3	74/-
Dalzell, No. 3 (special)	102/6 to 105/-
Glengarnock, No. 3	82/-
Clyde, No. 3	82/-
Monkland, No. 3	82/-
Summerlee, No. 3	82/-
Eglinton, No. 3	82/-
Gartsherrie, No. 3	82/-
Shotts, No. 3	82/-

FINISHED IRON AND STEEL

Usual district deliveries for iron; delivered consumer's station for steel.

Iron—	£ s. d.	£ s. d.
Bars (cr.)	9 12 6	to 9 15 0
Nut and bolt iron	7 10 0	to 8 0 0
Hoops	10 10 0	and up.
Marked bars (Staffs)	f.o.t. 12 0 0	
Gas strip	10 10 0	and up.
Bolts and nuts, ¾ in. × 4 in.	14 2 6	and up.

Steel—	£ s. d.	£ s. d.
Plates, ship, etc.	8 15 0	to 8 17 6
Boiler plts.	9 5 0	to 9 7 6
Chequer plts.	10 7 6	
Angles	8 7 6	
Tees	9 7 6	
Joists	8 15 0	
Rounds and squares, 3 in. to 5½ in.	9 7 6	
Rounds under 3 in. to ⅝ in. (Untested)	8 12 0	
Flats—8 in. wide and over	8 12 6	
,, under 8 in. and over 5 in.	8 17 6	
Rails, heavy	8 5 0	to 8 10 0
Fishplates	12 5 0	to 12 10 0
Hoops (Staffs)	9 7 0	
Black sheets, 24g. (4-t. lots)	10 10 0	
Galv. cor. shts. (,,)	13 0 0	
Galv. flat shts. (,,)	13 10 0	
Galv. fencing wire, 8g. plain	14 10 0	
Billets, soft	5 10 0	and up.
Billets, hard	6 17 6	to 7 2 6
Sheet bars	5 2 6	to 5 7 6
Tin bars	5 5 0	to 5 7 6

PHOSPHOR BRONZE

	Per lb. basis.
Strip	9 3/4d.
Sheet to 10 w.g.	11 1/2d.
Wire	11 3/4d.
Rods	11d.
Tubes	13 1/2d.
Castings	12d.

Delivery 3 cwt. free.
10% phos. cop. £30 above B.S.
15% phos. cop. £35 above B.S.
Phosphor tin (5%) £30 above price of English ingots.
C. CLIFFORD & SON, LIMITED.

NICKEL SILVER, &c.

	Per lb.
Ingots for raising	7d. to 1/1
Rolled—	
To 9 in. wide	1/1 to 1/7
To 12 in. wide	1/1½ to 1/7½
To 15 in. wide	1/1½ to 1/7½
To 18 in. wide	1/2 to 1/8
To 21 in. wide	1/2½ to 1/8½
To 25 in. wide	1/3 to 1/9
Ingots for spoons and forks	7d. to 1/3½
Ingots rolled to spoon size	10d. to 1/6½
Wire round—	
to 10g.	1/4½ to 1/11½

with extras according to gauge.
Special 5ths quality turning rods in straight lengths, 1/3½ upwards.

AMERICAN IRON AND STEEL

At Pittsburgh unless otherwise stated.

	Dols.
No. 2 foundry, Phila.	20.31
No. 2 foundry, Valley	18.50
No. 2 foundry, Birm.	14.50
Basic, Valley	18.00
Malleable, Valley	18.50
Grey forge, Valley	18.00
Ferro-mang. 80%, seaboard	85.00
O.-h. rails, h'y, at mill	36.37½
Billets	27.00
Sheet bars	28.00
Wire rods	38.00
	Cents.
Iron bars, Chicago	1.80
Steel bars	1.80
Tank plates	1.80
Beams, etc.	1.80
Skelp, grooved steel	1.70
Steel hoops	2.10
Sheets, black, No. 24	2.40
Sheets, galv., No. 24	3.10
Wire nails	2.60
Plain wire	2.30
Barbed wire, galv.	3.00
Tinplates, 100-lb. box	$5.25

COKE (at ovens)

Welsh foundry	25/- to 30/-
,, furnace	19/- to 20/-
Durham foundry	19/- to 22/-
,, furnace	16/6 to 17/9
Scotland, foundry	28/-
,, furnace	25/-

TINPLATES

f.o.b. Bristol Channel ports.

I.C. cokes	20×14 per box	18/2 and up.
,,	28×20 ,,	36/4 and up.
,,	20×10 ,,	26/-
,,	18¾×14 ,,	18/9
C.W.	20×14 ,,	15/3 to 15/6
,,	28×20 ,,	32/6 to 33/-
,,	20×10 ,,	23/- to 23/3
,,	18¾×14 ,,	15/6 to 15/9

SWEDISH CHARCOAL IRON & STEEL

	£ s. d.	£ s. d.
Pig-iron	£6 0 0	to £7 0 0
Bars-hammered, basis	£16 0 0	to £16 10 0
Bars and nail-rods, rolled, basis	£15 15 0	to £16 0 0
Blooms	£10 0 0	to £12 0 0
Keg steel	£30 0 0	to £31 0 0
Faggot steel	£18 0 0	to £23 0 0
Bars and rods dead soft, st'l	£10 0 0	to £12 0 0

All per English ton, f.o.b. Gothenburg
[Subject to an exchange basis of Kr. 18.16 to £1.]

DAILY FLUCTUATIONS

Standard Copper (cash)

	£	s.	d.		
July 11 ..	31	1	3	inc.	15/–
,, 12 ..	31	2	6	,,	1/3
,, 15 ..	32	1	3	,,	18/9
,, 16 ..	32	2	6	,,	1/3
,, 17 ..	31	13	9	dec.	8/9

Electrolytic Copper

	£	s.	d.		
July 11 ..	34	0	0	inc.	10/–
,, 12 ..	34	0	0	No	change
,, 15 ..	35	10	0	inc.	30/–
,, 16 ..	35	10	0	No	change
,, 17 ..	35	5	0	dec.	5/–

Standard Tin (cash)

	£	s.	d.		
July 11 ..	231	2	6	inc.	2/6
,, 12 ..	231	5	0	,,	2/6
,, 15 ..	232	0	0	,,	15/–
,, 16 ..	232	10	0	,,	10/–
,, 17 ..	232	15	0	,,	5/–

Tin (English ingots)

	£	s.	d.		
July 11 ..	231	5	0	inc.	5/–
,, 12 ..	231	10	0	,,	5/–
,, 15 ..	232	5	0	,,	15/–
,, 16 ..	232	10	0	,,	5/–
,, 17 ..	232	15	0	,,	5/–

Spelter (ordinary)

	£	s.	d.		
July 11 ..	13	18	9	inc.	5/–
,, 12 ..	13	16	3	dec.	2/6
,, 15 ..	13	17	6	inc.	1/3
,, 16 ..	13	17	6	No	change
,, 17 ..	13	16	3	dec.	1/3

Spelter (Electro, 99.9 per cent.)

	£	s.	d.		
July 11 ..	16	10	0	inc.	5/–
,, 12 ..	16	7	6	dec	2/6
,, 15 ..	16	8	9	inc.	1/3
,, 16 ..	16	8	9	No	change
,, 17 ..	16	7	6	dec.	1/3

Zinc Sheets (English)

	£	s.	d.		
July 11 ..	23	0	0	inc.	2/6
,, 12 ..	22	17	6	dec.	2/6
,, 15 ..	22	17	6	No	change
,, 16 ..	22	17	6	,,	,,
,, 17 ..	22	17	6	,,	,,

Lead (English)

	£	s.	d.		
July 11 ..	16	0	0	No	change
,, 12 ..	16	0	0	,,	,,
,, 15 ..	16	0	0	,,	,,
,, 16 ..	16	0	0	,,	,,
,, 17 ..	16	5	0	inc.	5/–

Imports and Exports of Pig-Iron, Iron and Steel Castings, etc., in June and the six months, 1935, compared with a year ago.

	June.		Six months.		June.		Six months.	
	1934.	1935.	1934.	1935.	1934.	1935.	1934.	1935.
	Tons.	Tons.	Tons.	Tons.	£	£	£	£
Imports.								
Pig-iron—from British India	1,486	6,311	48,972	38,925	4,441	21,187	134,451	117,990
,, Foreign Countries	1,295	1,785	7,083	7,334	7,322	10,444	41,106	43,065
Total	2,781	8,096	56,055	46,259	11,763	31,631	175,557	161,055
Castings and forgings	422	41	1,990	1,355	10,850	1,206	50,020	35,611
Cast pipes and fittings	86	321	655	619	4,359	4,668	35,455	17,719
Stoves, grates, etc.	85	81	428	529	7,524	7,327	41,227	48,508
Baths	417	575	3,831	3,290	11,107	14,845	92,842	89,128
Hollow-ware, all kinds	267	250	1,284	1,274	13,742	15,205	70,417	85,305
Exports.								
Pig-iron, forge	127	87	589	741	535	467	2,410	3,305
,, foundry	5,739	7,448	34,634	46,233	21,295	25,540	119,013	161,158
,, acid	3,549	3,024	23,690	26,279	11,267	10,324	74,884	85,460
,, basic	—	—	778	231	—	—	2,523	727
Total	9,415	10,559	59,691	73,484	33,097	36,331	198,830	250,650
Castings and forgings	378	360	2,461	2,054	14,438	16,085	91,902	80,678
Cast pipes and fittings, up to 6 in. diameter	5,651	5,967	31,003	27,977	60,968	63,522	343,336	309,321
,, ,, ,, over 6 in. ,,	2,210	3,462	19,581	19,536	16,965	25,477	146,685	149,598
Stoves, grates, etc.	691	670	4,179	4,128	31,897	35,361	197,481	204,533
Sanitary cisterns	234	264	1,435	1,529	7,424	7,808	42,504	43,577
Bedsteads, inc. tubes therefor	456	310	2,641	2,185	14,950	11,267	86,164	78,594
Cast hollow-ware	324	266	1,692	1,886	11,773	10,592	64,600	73,554

WILLIAM JACKS & COMPANY,

WINCHESTER HOUSE, OLD BROAD ST., LONDON, E.C.2.

CLARENCE CHAMBERS, 39, CORPORATION STREET, BIRMINGHAM.

13, RUMFORD STREET, LIVERPOOL.

PIG

IRON

All grades FOUNDRY, HEMATITE, BASIC, SPECIALS, &c.

NON-FERROUS METALS

COPPER, TIN, LEAD, SPELTER, ANTIMONY, CHROME ORE.

WILLIAM JACKS & COMPANY,

CENTRAL CHAMBERS, 93, HOPE ST., GLASGOW, C.2.

ZETLAND ROAD, MIDDLESBROUGH.

SITUATIONS VACANT AND WANTED

IRONMOULDER, accustomed good class light and medium cylinder and general works, seeks job. Any district.—Box 322, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

BUYER and Cost Man required by iron-founders. Must have done similar work and knowledge of use of foundry materials essential. State age, experience and salary required.—Box 318, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

THE UNIVERSITY OF SHEFFIELD.

ASSISTANT LECTURER IN METALLURGY (FOUNDING).

THE Council are about to appoint an Assistant Lecturer in Metallurgy (Founding). Salary £300 per annum. Further particulars may be obtained from the undersigned, with whom applications should be lodged by July 31.

W. M. GIBBONS.
Registrar.

WANTED, an experienced man to take charge of a large cupola plant melting 1,000 tons of cast iron per day. Apply, giving age and experience, to THE STANTON IRONWORKS COMPANY, LIMITED, near Nottingham.

WANTED FOR INDIA. Assistant Foundry Foreman, age 25 to 28. Must have experience of light castings (general jobbing, rainwater and soil, from shell and plate patterns). Experience in patternmaking and technical knowledge desirable. 4½ years' engagement. Commencing salary Rs. 450 to Rs. 500 per month, with free unfurnished quarters and passage out and home. Applications stating age, experience, to "BENGAL," c/o Advertisement Dept., 5, New Bridge Street, London, E.C.4.

WANTED FOR INDIA. Foundry Foreman, age about 30, with experience moulding of general castings in dry sand, green sand, and loam up to 20 tons weight; also pipes and special castings to B.S.S. Should have had two years as foundry foreman, assistant or chargeman. Technical knowledge desirable. 4½ years' engagement. Commencing salary Rs. 500 to Rs. 600 per month, with free unfurnished quarters and passage out and home. Excellent prospects for suitable man. Applications stating age, experience, to "FOUNDRY," c/o Advertisement Dept., 5, New Bridge Street, London, E.C.4.

EMPLOYMENT REGISTER.

Conducted by the Institute of British Foundrymen by courtesy of the proprietors of THE FOUNDRY TRADE JOURNAL.

Correspondence should be addressed to the General Secretary, Institute of British Foundrymen, St. John Street Chambers, Deansgate, Manchester, from whom full particulars can be obtained of this service.

Any employer wishing to communicate with a candidate should write to the General Secretary, quoting identification number.

YOUNG MOULDER requires position as Moulder or in charge. Excellent experience iron (repetition work), brass, aluminium and special alloys. Technical training. (265)

PROPERTY

TO BE LET in Willesden District, small experimental Foundry or Workshop, 1,600 sq. ft., fitted with Morgan's "P" 2-type oil-fired furnace, with self-contained electric-motor-driven fan, small lathe, grinder, drilling machine, and various woodworking and lathe tools; to be taken at valuation.—Box 314, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

MACHINERY

WANTED. Second-hand Cupola, 3 to 3½ tons per hr. capacity. State where can be inspected in reply to Box 316, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

WANTED. Second-hand sandslinger moulding machine.—Box 320, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

LADLES IN STOCK.

30-ton Stevenson ladle, £75.
25-ton Stevenson ladle (new), £70.
10-ton Evans ladle (as new), £40.
6-ton Evans ladle (as new), £30.
5-ton Evans ladle (as new), £28.
A. HAMMOND, 14, Australia Road, Slough.

SANDBLAST PLANTS

Room Plants, sizes 12 ft. x 12 ft., 12 ft. x 9 ft. and 6 ft. x 6 ft., made up in cast-iron sections.

Barrel Plants, 30 in. dia. x 36 in. long and 30 in. dia. x 18 in. long rotary barrels.

Cabinet Plants, in sizes 4 ft. x 4 ft. x 4 ft., 36-in. dia. and 30-in. dia. operators' cabinets.

Most of the above by Tilghman and complete with Air Compressors.

HAND MOULDING MACHINES

By Adaptable, Fridmore, Darling & Sellars, etc.; Squeezers by Utard (unused), Samuelson and Britannia, also Farwell Universal Type.

Ladles, Grinding Machines, Exhaust Fans, Blowers, Air Compressors and 500 Electric Motors and Dynamos.

S. C. BILSBY, A.M.I.C.E., A.M.I.E.E.
CROSSWELLS ROAD (Adjoining Railway Crossing), LANGLEY, Nr. Birmingham.
'Phone: Broadwell 1359.

THOS. W. WARD LTD.

10-cwt. COMPRESSED-AIR HAMMER (Glen & Ross), 10" dia. cyl., 20" stroke; pallet face 11½" x 9".

6-cwt. COMPRESSED-AIR HAMMER (Musker), 8" dia. cyl., 20" stroke; pallet face 18½" x 6".

Three LANCS. BOILERS, 30' x 8', 150 lbs. w.p.

Write for "Albion" Catalogue.

Grams: "Forward." 'Phone: 23001 (10 lines).
ALBION WORKS, SHEFFIELD.

'Phone: 287 SLOUGH

MOULDING MACHINES

J 75 OSBORN jolt squeezer.
406 OSBORN jolt rollover.
18"×36" "Shockless" TABOR rollover.
24"×48" "Shockless" TABOR rollover.
30"×40" "Shockless" TABOR rollover.

SANDBLAST PLANTS

8'×8'×8' Tilghman room plant with Tilghman compressor and all equipment, practically new plant throughout.

12' × 9' Tilghman sandblast room, built of cast iron plates, complete with 400 cu. ft. Tilghman air compressor and all accessories. FINE PLANT.

T.B. 4 Tilghman sandblast barrel plant, complete. Size of barrel 60" × 40".

T.B. 1 Tilghman sandblast barrel 30"×20".

BUY FROM ME AND SAVE MONEY!

ALEX. HAMMOND, *Foundry Machinery Merchant,*
14, AUSTRALIA ROAD, SLOUGH

MACHINERY—*Continued*

NEW Dwarf Cupola, to melt 10 to 15 cwts. per hr. New Worm-geared Ladles, 5 tons, 25 cwts., 15 cwts. and 10 cwts. capacity. Ungeared Ladles, 15 cwts. and 10 cwts. capacity. Improved Cupola Spark Arresters.—T. DAVIES & SON, West Gorton, Manchester.

SELECT YOUR MACHINE FROM THE LARGEST STOCK OF HIGH CLASS SECONDHAND MOULDING MACHINES IN THE WORLD

Practical Advice Free

THE COLEMAN FOUNDRY EQUIPMENT CO., LTD.,
156, STRAND, LONDON, W.C.2.

WHEN THINKING OF
SANDBLAST
THINK OF
RICHARDSON'S
Established 1887.

We Supply Re-Conditioned & New
SAND BLAST PLANTS
AND
AIR COMPRESSORS.

Tilghman's, Room, Barrel, Chamber, Rotary Table, Dust Arrester, and Continuous Feed Barrel Plants.

Phone: MIDLAND 2281.
Grams: "SANDBLAST, B'HAM."
R. J. RICHARDSON & SONS, Ltd.,
Commercial Street, Birmingham.

IDAHO PINE
YELLOW PINE

PRIME & PATTERN GRADES
½" to 3" thick
Width up to 24" wide
All free of centre heart and shake

CHETHAM TIMBER Co., Ltd.,
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